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Thrips Investigation.

2. Some Factors that Regulate the Abundance of *Thrips imaginis* Bagnall.*

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The work described in the article that follows forms a part of the programme of the investigations which are being undertaken as a co-operative enterprise between the Council for Scientific and Industrial Research, the Waite Agricultural Research Institute of the University of Adelaide, certain State Departments of Agriculture, and the Thrips Investigation League. The work itself has been placed under the direction of the Chief Entomologist at the Waite Institute, Dr. J. Davidson; further details of the arrangements were published a little time ago (this *Journal* 6: 216, 1933). The Thrips Investigation League is a body that was set up by fruit-growers, merchants, and others concerned in the fruit industry, soon after the disastrous thrips year of 1931. Its objects are to stimulate the investigation of the thrips problem, and to collect funds to supplement those made available by research organizations studying that problem.—Ed.

Summary.

Daily records of the thrips present in roses have been kept for two consecutive years. In addition, samples have been taken of the spring populations in Cape weed (*Cryptostemma calendulaceum*) and salvation jane (*Echium plantagineum*) flowers. The data accumulated show the close correlation between the autumn and spring thrips populations, and demonstrate how the increase and decrease of the population is directly dependent upon meteorological conditions. In this paper, special attention is paid to rainfall as a factor limiting thrips abundance.

1. Introduction.

In previous publications, evidence was brought forward to demonstrate the close correlation between meteorological conditions and thrips abundance. In one paper (Coun. Sci. Ind. Res., Pamphlet 30, 1932) it was shown how an examination of meteorological records disclosed the fact that infestations of thrips in the spring invariably followed winters during which the rainfall was above the average, and in particular the rainfall during May or June had been abnormally heavy.

* The first paper of this series appeared in this *Journal* 6: 145, 1933.

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It was also shown that, during the actual months when thrips were abundant, the prevailing temperatures were high and the rainfall low.

In a further paper (*J. Coun. Sci. Ind. Res.*, **6**: 145, 1933), it was suggested that the numbers of individuals comprising the first spring generation determined the possibilities of a subsequent infestation, and that the numbers present in that generation were dependent especially on the meteorological conditions of the preceding four months. In the present paper, evidence based on actual records of thrips abundance during two seasons is brought forward in support of this hypothesis, and it is shown in what manner the incidence and amount of rainfall affects the population numbers.

2. Soil Moisture Experiments.

If the separate stages of the life-cycle are considered in turn, it is apparent that it is during the pupal instars that the insect is least resistant to unfavorable climatic influences. The eggs are actually embedded in plant tissue, and unless the tissue shrivels before they hatch, they are not subject to desiccation. Both nymphs and adults can withstand high temperatures and a high saturation deficiency, so long as they have access to food and can maintain their water balance.

When the nymphs stop feeding and enter the soil, they are dependent on the moisture of their environment for their water requirements, both while still in the last nymphal instar and during the periods spent as pre-pupae and pupae. During these stages, they retain their power of movement, and can reach favorable, local situations if such are available in their immediate neighbourhood; but they form no protective cells, and their cuticle does not harden. Consequently, they are liable to suffer desiccation if sufficient moisture is not available. It has been shown experimentally that nymphs will burrow to a considerable depth in search of moisture, and that they will pupate near the surface of the soil if it is sufficiently damp.

During the spring of 1933 a series of experiments, to determine the effect of different degrees of soil moisture, were carried out in the manner discussed in the paragraphs that follow.

Fully mature nymphs were collected from the flowers of salvation jane and transferred by means of a camel's-hair brush, to plaintain flower heads (*Plantago lanceolata*). The plantain stalks were embedded in soil contained in circular cells excavated in large corks, the cells being .5 inch deep and 1.0 inch in diameter; the corks were 1.5 inches deep and 2.0 inches in diameter. A cotton-wool wick passed from the base of each cell to the bottom of each cork. When the plantains were in place, each cork was fitted into the base of a glass lamp chimney (6 inches high), the top of the chimney being covered with cellophane. Water was added to the soil by placing the corks in petri dishes containing water. As soon as the surface of the soil was observed to be evenly wet, the soil was considered saturated, and the containers were then placed in a soil-temperature tank.* After 24 hours, the plantains and consequently any thrips that had not entered the soil, were removed.

* An electrically-heated incubator containing ten vertical cells in which the containers were placed, their tops not quite reaching the surface of the tank. The cells were not covered, and it was found that, at the temperature employed for these tests, there was little or no fluctuation in temperature at the bottom of the cells.

All experiments were carried out at a temperature of 21.5°C. At this temperature the emergence of adults commenced on the 7th day (this includes the day on which the tests began); the greatest numbers emerged on the eighth and ninth days, and small numbers continued to appear on the tenth and eleventh days. By carrying out tests with individuals in glass tubes containing moist cotton wool, it was ascertained that at least three days elapsed from the time the nymphs entered the soil until they became pre-pupae; one day was spent in the pre-pupal stage and a minimum of two days in the pupal stage.

With the first series of experiments, one set of containers was filled with air-dry soil, and another with soil that was saturated daily. Further series, in which the soil was saturated at varying intervals followed. It was found that the greatest emergence resulted when the soil was wet on the first day and on the sixth day, that is, on the day the nymphs entered the soil and one day before the maximum emergence was due. The soil moisture of the saturated soil was 26 per cent., and of the air-dry soil 3 per cent. (calculated on the wet soil basis). The results of these experiments are set out in the table on page 64. The figures in dark type indicate the days on which the soil moisture was made up to saturation.

3. Population Records.

For the purpose of recording the seasonal fluctuations in thrips abundance, sample counts have been taken of the numbers present in roses, salvation jane (*Echium plantagineum*), and Cape weed (*Cryptostemma calendulaceum*). The daily records of the populations in roses have been taken for two years; daily counts of the thrips present in the flowers of the other species of plants have been made during the spring in two consecutive years. The roses used each year were picked from identical hedges, twenty flowers being picked each day; the Cape weed and salvation jane flowers were taken from the same areas each season, 50 flowers of each being examined daily. The sampling methods employed have been described previously (*J. Coun. Sci. Ind. Res.*, **6**: 145, 1933), and the daily records for 1932 were given in the same paper.

In Fig. 1, curves are plotted representing thrips abundance, together with the average maximum shade temperatures and the rainfall, for the months of March to October for the years 1932 and 1933. Each point represents a ten or eleven-day period. The thrips curve for 1933 is plotted from the same figures as those previously published (*J. Coun. Sci. Ind. Res.*, **6**: 145, 1933), but in the present figure the curve represents the total population, the sexes not being plotted separately as before.

4. Discussion of Fig. 1.

The most striking feature of Fig. 1 is the close correlation between the numbers of the autumn and spring thrips population during both years.

Before drawing attention to the salient features of the temperature and rainfall curves, it is necessary to consider the weather conditions and thrips populations during those months of the year not included in the figure. In 1932, the adult thrips population in roses reached its highest level during the first ten-day period of December; in 1933

EMERGENCES OF *Thrips imaginis* FROM SOIL AT VARIOUS SOIL MOISTURES, AND AT A TEMPERATURE OF 21.5C°.

Number.	Number of Tests.	Total Number of Nymphs.	Soil Moisture (per cent.).									Percentage Emergence.
			1st day.	2nd day.	3rd day.	4th day.	5th day.	6th day.	7th day.	8th day.	9th day.	
1	1	50	**26·08**	23·30	14·31	10 38	9·53	**26·08**	..	..	..	72
2	3	150	**26·08**	23·30	14·31	10·38	**26·08**	23·30	..	..	..	64
3	2	100	**26·08**	23·30	14·31	10·38	9·53	5·01	..	..	..	51
4	1	50	**26·08**	23·30	**26·08**	23·30	**26·08**	23·30	..	..	..	48
5	4	180	**26·08**	**26·08**	**26·08**	**26·08**	**26·08**	**26·08**	**26·08**	**26·08**	**26·08**	46
6	1	50	3·00	**26·08**	23·30	14·31	10·38	**26·08**	..	..	..	12
7	1	50	3·00	3·00	**26·08**	23·30	14 31	10·38	**26·08**	..	..	8
8	2	100	3·00	3·00	3·00	**26·08**	23·30	14·31	..	..	..	0
9	1	50	3·00	3·00	3·00	3·00	**26·08**	23·30	..	..	..	2
10	2	100	3·00	3·00	3·00	3·00	3·00	**26·08**	..	..	..	0
11	4	180	3·00	3·00	3·00	3·00	3·00	3·00	3·00	3·00	3·00	0

this occurred during the last ten-day period of November. In both years, the peak populations were followed by sharp falls. It is thus apparent that the conditions during the periods immediately preceding the peaks were favorable for thrips development; also, that during the time when the greatest number of adults were actually in evidence, the

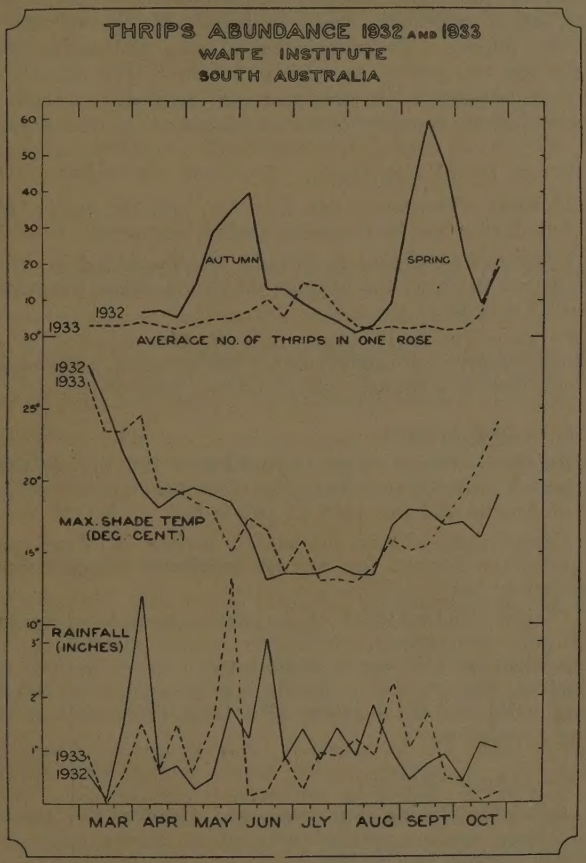

Fig. 1.—Curves showing thrips abundance at the Waite Institute, together with average maximum shade temperatures and rainfall for the months of March to October in the years 1932 and 1933.

low soil moisture was unfavorable for the development of the pupal stages. As the summer advances, the soil moisture decreases, and it is considered that the principal factor responsible for the sudden drop in numbers at this period, and the maintenance of the population at a low level of abundance until the autumn, is the low soil moisture (this may be below 5 per cent. in the surface mulch).

The drop in numbers earlier in 1933 than in 1932 is explained by an examination of the rainfall records for October and November. In 1932, the total rainfall for the two months was 3.01 inches, and the rainfall evaporation ratio .27. The corresponding figures for 1933, are .94 and .08. These figures show that the soil dried out later in 1932 than in 1933. At the end of the summer and at the beginning of autumn, no appreciable increase in the numbers of thrips will occur until the soil is sufficiently moist to permit of the survival of the nymphs and pupae. The meteorological data and thrips abundance curves for the two years are correlated below; for convenience, the eight months concerned, in each year, are divided into three periods. The meteorological data are discussed in periods of ten days.

1932. *Period* 1.—(March-June).

(*a*) *Rainfall.*—Following the hot dry summer, heavy rain (3.8 inches) fell during the first ten-day period in April.

(*b*) *Temperature.*—From the second ten-day period in April until the first period in June, the average maximum shade temperature lay between 20° and 15°C.

(*c*) *Thrips.*—The early, heavy falls of rain, followed by 60 days of optimum temperature conditions for reproduction, resulted in a rise in numbers during a period comprising two generations.

Period 2.—(June-August).

(*a*) *Rainfall.*—Heavy rains (3.10 inches) fell during the second ten-day period in June, and during no subsequent ten-day period, until the end of August, did less than 75 points fall.

(*b*) *Temperature.*—From the second period in June until the second period in August, the average maximum shade temperatures were uniformly below 15°C.

(*c*) *Thrips.*—The majority of the mature nymphs (progeny of the second autumn generation), would have entered the soil during June, at a time when the soil was well saturated. Since the soil remained moist, and the temperature uniformly low throughout the winter, good conditions ruled for the survival of a large proportion of the over-wintering population.

Period 3.—(August-October).

(*a*) *Rainfall.*—During September and October, the rainfall was relatively high, over an inch of rain falling during both of the two last ten-day periods in October.

(*b*) *Temperature.*—The average maximum shade temperatures were above 15°C., but below 20°C., for each of the six periods in September and October.

(*c*) *Thrips.*—The emergence of the first spring generation began during the last period in August, when the average maximum shade temperature reached 17°C. Although the temperature during the two succeeding months was favorable for the emergence of the first spring generation, it was too low to permit rapid reproduction. Consequently, the numbers fell during October, since deaths or losses due to dispersal were not replaced immediately.

1933. *Period* 1.—(March-June).

(*a*) *Rainfall.*—The first heavy autumn rains fell during the last ten-day period in May; the rainfall in June was low (1.1 inches falling during the whole month).

(*b*) *Temperature.*—Since the soil-moisture was unfavorable for the survival of pupae until after the rain in May, the temperature before this period need not be considered. The temperature during the first two periods in June lay between 20°C. and 15°C. and below 15°C. during the last period.

(*c*) *Thrips.*—Favorable temperatures and soil moisture during the first two-thirds of June resulted in an increase of the thrips population during one generation. The numbers fell with the drop in temperature at the end of the month.

Period 2.—(July-August).

(*a*) *Rainfall.*—Only 16 points (0.16 inches) of rain fell during the first ten-day period in July. During the next 50 days the precipitation was similar to that of the corresponding period in 1932.

(*b*) *Temperature.*—The average maximum shade temperature rose to 15.8°C. during the first period in July, remained below 15°C. for the next 40 days, and rose to 15.8°C. during the last period in August.

(*c*) *Thrips.*—The rise in temperature at the beginning of July was accompanied by a corresponding increase in the number of adult thrips. There was, however, no rise in the thrips population during the last period in August.

Period 3.—(September-October).

(*a*) *Rainfall.*—The rainfall steadily decreased from the middle of September until the end of October.

(*b*) *Temperature.*—After a slight drop at the beginning of September, the temperature steadily rose. The average maximum shade temperature for the last ten-day period in October was 24.2°C.

(*c*) *Thrips.*—Low rainfall, accompanied by high temperatures during the early spring, favour thrips emergence and increase in numbers. No increase occurred in September or at the beginning of October. The small increase in numbers which occurred in the previous autumn was dissipated by the premature emergence of the thrips in winter (July). The numbers in the first spring generation were therefore small; the increase in numbers at the end of October represents the appearance of the second spring generation.

5. Salvation Jane and Cape Weed Records.

The curves in Fig. 2 represent the spring thrips populations in salvation jane and Cape weed flowers during 1932 and 1933. As in Fig. 1, the points plotted represented ten-day periods. Two generations are represented, the first spring generation (the progeny of the second autumn generation) and the second spring generation. It will be noticed that, as in the case of the roses, the population of thrips in these plants was high in 1932 and low in 1933, thus affording evidence that the thrips population in roses was fairly typical of the populations of these insects in all host plants.

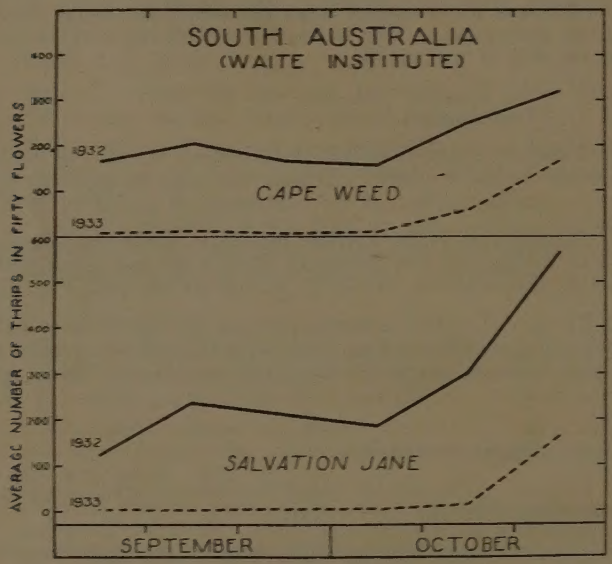

FIG. 2.—Curves showing the spring thrips populations in salvation jane and Cape weed flowers during 1932 and 1933.

6. Discussion.

The purpose of this paper has been to present evidence of the previously assumed hypothesis, that the weather conditions ruling during the autumn and winter largely determine the magnitude of the initial spring population of thrips, and hence the possibilities of an infestation. Two years have been discussed. During one (1932), the autumn weather conditions allowed an increase of the thrips population during two successive generations. The winter weather conditions were favorable, and in spite of a cold wet spring, the thrips numbers rose in September.

In 1933, only a short period of suitable conditions for reproduction obtained during the autumn. Such increase in the population as did occur was largely dissipated as a result of a spell of warm dry weather during the winter. Consequently, although the weather during

October was hot and dry, in fact, such weather as is usually associated with an infestation, not only did none occur, but the numbers of thrips present during the spring months were negligible. Figures for the autumn thrips population in 1931 (an infestation year) are not available, but it is possible that one of the factors responsible for the very large numbers present during the spring of that year was the rainfall at the end of the summer (1 inch was recorded on 12th March). At the end of the summer, when evaporation is high, the influence of several days of light rain on the moisture in the soil will be of little significance, but a heavy fall during a short period must increase the soil moisture considerably. It is therefore possible that during the autumn of 1931 the moisture conditions permitted the favorable development of three consecutive generations as compared with two in 1932 and one in 1933.

Special attention has been paid to the effect of the abundance of thrips during the autumn on the numbers present in the succeeding spring. It is believed that this is a most important factor. There are undoubtedly other factors, and it is expected that when these records have been taken over a longer period an explanation will be possible of the effect of meteorological events in summer on the initial autumn numbers. It may well be shown that favorable weather during one year is not in itself sufficient to induce an infestation.

7. Conclusions.

The records presented in this paper have been made in Adelaide. In certain localities in south-eastern Australia local climates may have produced a different sequence of events. These places will be few, and, in general, it can be stated that the thrips numbers present during the past two years in eastern Australia (other than in Queensland and northern New South Wales) will have fluctuated somewhat as shown in Fig. 1. This statement is based on a comparison of the meteorological records of other areas and such records of thrips numbers as are available from other localities.

8. Acknowledgments.

The author is indebted to Dr. J. Davidson for suggestions and assistance, and particularly for his constant encouragement.

Thrips Investigation.

3. Some Observations on the loss of Toxicity of Certain Dusts Used in Experiments on the Control of the Apple Thrips (*T. imaginis* Bagnall).

*By H. W. Wheeler, B.Sc.**

(*From the Waite Agricultural Research Institute, University of Adelaide.*)

The work described in the article that follows was also carried out under the arrangements mentioned in the editorial to the previous paper (see page 61). In forwarding it for publication, Dr. Davidson has pointed out that the use of dusts containing pyrethrum and derris have given promising preliminary results, and that the observations contributed by Mr. Wheeler in regard to the toxicity of these substances are of considerable practical importance in this respect.—ED.

1. Introduction.

In the course of experiments on the control of the apple thrips (*Thrips imaginis* Bagnall), two vegetable poisons, pyrethrum and derris, have given marked success as contact insecticides in the form of dusts. In dusting apple trees for control of this thrips, it is important that the substance deposited on the blossoms should retain its toxic or repellent properties for an appreciable period during the critical stage. If the substance used remains active after two days' exposure on the tree, it may be considered satisfactory. Both pyrethrum and derris lose their strength on exposure, the main factor causing their deterioration being sunlight. Some preliminary experiments have been made with these substances exposed for different periods in order to determine their toxicity against *T. imaginis* and the relation between toxicity and chemical composition.

2. Pyrethrum.

This substance, a yellow powder obtained by crushing the dried flowers of certain species of *Chrysanthemum*, has long been in use as a household insecticide powder, and as a constituent of fly-sprays. The active principles are esters of a ketonic alcohol, pyrethrolone, with two acids of similar structure, and are known as pyrethrin I. and pyrethrin II. The pyrethrins, which are viscous liquids, usually occur to the extent of less than 1 per cent. in the pyrethrum powder. Pyrethrin I. is, in many cases, considerably more active against insects than pyrethrin II., and it has been shown (H. Richardson, *J. Econ. Ent.* **24**: 1098, 1931) that the pyrethrin I. content of powders from which fly-sprays were made could be taken as an index of the insecticidal efficiency of the spray.

In the following tests, small quantities of pyrethrum having a known content of pyrethrin I. were exposed to sunlight for definite periods; the amount of pyrethrin I. remaining after the period of

* Chemist assisting with the insecticide work of the co-operative thrips investigations centred at the Waite Institute (see this *Journal* 6 : 216, 1933).

photo-chemical decomposition was estimated in each case. The main sample of pyrethrum was kept stored in the dark. Lots of 25 grams each were spread out in thin layers in shallow zinc trays, and exposed to bright sunlight for varying periods. While the dusts were not undergoing exposure, they were stored in the dark. The influence of temperature and moisture on the photo-chemical reaction has not been considered. Only pure pyrethrum was used, but it is possible with dusts that the rates of decomposition will vary with different carriers. The pyrethrin I. content was determined by the short acid method of Tattersfield (*J. Agric. Sci.* **19** : 433, 1929). Preliminary tests for each sample of pyrethrum were carried out by placing one apple blossom bud, dusted with the pyrethrum powder, in a tube with 35 female *Thrips imaginis*. After standing 24 hours at room temperature, the numbers of thrips killed and repelled were counted. The results are given below:—

Duration of Exposure to Sunlight (hours).	Pyrethrin I. (per cent.).	Thrips (per cent.).		
		Dead.	Alive in Flower.	Alive, but not in Flower.
..	0·20	94	..	6
1	0·15	..	..	..
2	0·12	37	3	60, mostly weak
4	0·076	17	0	83
8	0·043	37	3	60 (two tests)
25	0·040	0	29	71 (two tests)
45	0·038	6	23	71
Check	..	..	100	..

Upon inspection of the relation between pyrethrin I. content and duration of exposure, it is evident that the rate of deterioration is approximately proportional to the concentration of pyrethrin I. for about 8 hours. After this stage, the rate of photo-chemical decomposition falls off, and the powder contains an appreciable amount of pyrethrin I. even after 45 hours. This slackening of the rate of photo-chemical action might possibly be due to the fact that the grains of the powder become coated with layers of decomposed pyrethrins which protect the unaltered interior to some extent from further action. The insecticidal activity of the powder is seen to diminish as the time of exposure increases, and the pyrethrin I. content gives an approximate estimate of the toxicity of the deteriorated powder. The sample exposed 25 hours, which is roughly equivalent in properties to a dust which has remained on a fruit tree for 3 days, still has marked repellent properties towards the thrips.

In order to obtain an idea of the rate of decomposition of pyrethrum under conditions of dull daylight, a sample of the powder was exposed in the ordinary daylight of the laboratory for 25 hours. The pyrethrin I. content was then determined and found to be 0.12 per cent., equivalent to that of the sample exposed to bright sunlight for 2 hours.

The characteristic odour of pyrethrum was noticed to diminish in intensity very quickly on exposure to light and air.

3. Derris.

This is a brownish powder, obtained by crushing the dried roots of certain tropical plants used as fish poisons, notably *Derris elliptica*. The active principles are substances of similar complex constitution, by far the most important of which is rotenone. This substance usually occurs to the extent of a few per cent., and can best be extracted by means of carbon tetrachloride. On re-crystallisation from alcohol, rotenone forms colourless, odourless crystals melting at 163° C. The value of a sample of derris as an insecticide is largely determined by its rotenone content. Rotenone and the related constituents of derris lose their toxicity on exposure to light, but at a much slower rate than that of the pyrethrins. The reaction is apparently one of photo-chemical oxidation, a yellow inert substance forming from the rotenone.

Rotenone was not as effective against the thrips as an equivalent amount of pyrethrin I., but derris dusts which contain a comparatively high percentage of rotenone gave favorable results. The lasting properties of a commercial derris insecticide were tested against the thrips, by comparing the properties of a fresh sample and one which had been exposed to bright sunlight, in a thin layer, for 25 hours. During the exposure, the characteristic odor of derris root was lost. The dust used in these tests contained crushed derris root, barium fluosilicate, and sulphur. The rotenone content of the samples was determined, after removing the sulphur, by the method of Jones (*Ind. Eng. Chem.* (Anal. Ed.), **5**: 36, 1933.) The results are given below:—

—	Rotenone (per cent.).	Thrips (per cent.)—85 used.		
		Dead.	Alive in Flowers.	Alive in Tube.
Fresh powder	1·5	99	0	1
Exposed 25 hours ..	0·9	65	4 (weak)	31 (weak)
Check	..	0	93	7

These preliminary observations on the behaviour of pyrethrum and derris have an important bearing on the use of these insecticides for the control of the apple thrips.

NOTE.—Tattersfield, F. (*J. Agric. Sci.*, 22: 396, 1932) has published an important paper dealing with the loss of toxicity of pyrethrum dusts on exposure to air and light, and has dealt with the influence of the incorporation of anti-oxidants with talc-pyrethrum and kieselguhr-pyrethrum dusts, in retarding their loss of activity due to exposure to light and air. Jones, H. A., and others (*J. Econ. Ent.* 26: 451, 1933), give the results of experiments on the loss of toxicity of deposits of rotenone and related materials exposed to light.

The Export of Chilled Beef—The Preparation of the "Idomeneus" Shipment at the Brisbane Abattoir.

By W. A. Empey, B.V.Sc., W. J. Scott, B.Agr.Sc.,* and J. R. Vickery, M.Sc., Ph.D.†*

Some of the results obtained by the Council's Section of Food Preservation and Transport in connexion with its investigations into the use of carbon dioxide in the storage of chilled beef were described in a previous issue (this *Journal* 6: 233, 1933). These results have now been followed up by the Queensland Meat Industry Board, which is co-operating with the Council in the latter's meat storage work (see this *Journal* 5: 133, 1932), and a large scale shipment of chilled beef has recently been sent by the Board to Great Britain per the M.V. *Idomeneus*. The conditions of that shipment are discussed in the following article.—Ed.

Summary.

The chief features of the preparation of the meat for the initial shipment of chilled beef from the Brisbane Abattoir are given. In order that chilled beef imported from Queensland may be landed in good condition in England, the microbial contamination, immediately post-slaughter, normally acquired under the conditions prevailing in most Australian meatworks, must be greatly reduced. The means by which this reduction was obtained are described, particular emphasis being given to the reduction from the chief sources of infection, viz., the hides and hoofs of the cattle. An altered chilling (pre-cooling) procedure was also introduced. The use of the new technique of slaughter, dressing, handling, and chilling normally results in the reduction of the contamination to approximately one-seventh of its former average.

Details are also given of the methods of handling and stowage employed in this shipment.

1. Introduction.

Since July, 1932, studies concerned with the prolonged storage of chilled beef have been in progress in the Council's laboratories at the Brisbane Abattoir. The experimental work has progressed sufficiently to enable the investigators broadly to indicate the conditions to be maintained in each phase of the works' treatment and overseas transport to enable chilled beef to be placed in good condition on the markets of Great Britain. In particular, the investigations have shown that, even with a period of storage equivalent to a relatively short voyage of 45 days from Queensland to Great Britain, extremely strict attention to cleanliness and certain alterations in existing technique in the meatworks, as well as the use in ships' holds of atmospheres containing 10 to 12 per cent. carbon dioxide, are essential to commercial success. In order to test these ideas under commercial conditions, the Queensland Meat Industry Board recently made arrangements with the agents for Messrs. Alfred Holt and Company's Blue Funnel Line to provide facilities for a small shipment to London on one of its vessels, M.V. *Idomeneus*. The Council co-operated with the Meat Board in this venture by giving technical advice, by collecting general data concerning the preparation in the abattoir, and by appointing an observer to travel with the shipment in order to collect data regarding the transport phase. Arrangements were also made for officers of the British Food Investigation Board to examine the beef on its arrival in London. Being, therefore, in possession of complete

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† Officer in Charge, Section of Food Preservation and Transport.

data, the Council's officers could thereby correlate the condition of the meat on the British markets with the treatment it had received prior to shipment.

2. Details Regarding Cattle.

Approximately 450 cattle, which had been rested for periods ranging from two to seven days, were slaughtered on behalf of six exporters. The meat so prepared was in excess of that required to fill the ship's chamber, but a selection of the best was made for export. The quality of the beef selected ranged from the poorer to the better types of the G.A.Q. grade, and the dressed weights of the carcasses varied from 560 to 900 lb.

The cattle were slaughtered on 6th February, 1934, and three days later the sides were cut down into quarters and the selected hindquarters and crops were stowed in the special chamber on the ship.

3. Slaughter and Dressing.

The hides and hoofs of the animals have been proved to be the main sources of the initial contamination of the beef by "low temperature type" micro-organisms.* Unless appropriate precautions are adopted, large numbers of micro-organisms are transferred from such sources to the carcasses by means of direct contact during dressing or by way of the slaughtermen's hands, arms, knives, and clothes. Of lesser importance in communicating microbial contamination to the surface of the meat are the washing brushes, the wiping cloths, the air of the slaughter floor, and the sawdust often used on the floors of the chilling rooms.

In consultation with the Council's officers, the Meat Board made many alterations and additions to the equipment of its larger beef slaughter floor, with the object of reducing the microbial contamination of the beef to the extent proved by the Council's investigations to be necessary for subsequent safe storage; and the schedule of the slaughter and dressing operations was thoroughly revised to exclude, or modify, any procedure likely to add microbial contamination. The chief features of the improvements installed were the thorough washing down of the cattle immediately prior to slaughter, the frequent sterilization of all utensils and instruments coming into contact with the surface of the beef, the provision of facilities to enable the slaughtermen and attendants frequently to wash their arms and hands, the provision of an ample supply of clean, moist, sterilized wiping cloths, and the regular, thorough cleansing of the slaughter floor and chilling rooms. It is essential to bear in mind that the modified procedure of slaughter and dressing could scarcely be successful without the full interest and co-operation of the men employed on the slaughter floor; excellent co-operation occurred during the preparation of this consignment of beef.

Notwithstanding the altered procedure, the slaughter of the cattle was maintained at the normal rate, and the average time from the knocking down of the cattle to the entrance to the chilling rooms of the dressed sides of beef was approximately 45 minutes.

* Bacteria, moulds, and yeasts capable of comparatively rapid growth, under suitable conditions, at temperatures of the order of —1° C. (30.2° F.) may conveniently be referred to as "low temperature types."

4. Chilling of the Beef.

Several days prior to the preparation of the beef, the chilling rooms were sterilized with gaseous formaldehyde, and this operation served also to sterilize the brine employed in the refrigeration system. Shortly before slaughtering commenced, the walls and floors were thoroughly cleaned and sterilized.

The two chilling rooms employed for the cooling of the experimental consignment had been reconstructed on the basis of empirical data obtained by the Council's investigators, the conditions aimed at being rapid cooling of the beef, particularly during the first twelve hours, and also the production of a relatively dry surface on the meat. Numerous experiments have indicated that, if these conditions are not attained and if cleanliness is not maintained in the rooms, the maximum period of storage of the beef may be reduced by as much as ten to fourteen days.

Each room (total capacity 500 sides) was loaded with about 450 sides of beef hung from five rails, charging being commenced at 8.30 a.m. and completed at 3.45 p.m.

Physical data were obtained relating to the rate of cooling of the superficial and internal portions of "standard" sides of beef weighing 350 pounds (approximately), and also of the temperature, relative humidity, and rate of movement of the air in the rooms. These data showed that the rate of cooling and loss of superficial moisture of the "standard" sides were satisfactory. For instance, the average superficial temperature taken at four "standard" points $\frac{1}{4}$ inch to $\frac{1}{2}$ inch below the surface on a number of sides fell to 10°C. (50°F.) within eleven hours after the sides were placed in the rooms, while the temperature of the thickest portion of the sides (350 lb.)—the buttocks—fell to an average of 0.5°C. (33°F.) in 67 hours. The average moisture contents of the outer $\frac{1}{2}$ mm. layers of the muscle around the aitch bone and neck areas of ten sides, taken immediately prior to removal from the chilling rooms, were 44.1 per cent. and 51.4 per cent. respectively; a moisture content below 55 per cent. (approximately) is considered essential. The beef was firm and superficially dry without the appearance of any noticeable "withering."

5. Transfer of Beef to Ship.

The sides were cut down into hindquarters and crops in a cold air lock, strict attention being paid to the cleanliness of the hands and clothes of the men handling the beef, and also of the knives and saws employed in this operation. The quarters were each wrapped in two sterilized stockinette covers, and, hanging in a goods lift, were removed to ground level, where they were transferred to the rails of high trolleys. The latter had only to be moved a distance of about 50 yards to the ship's side. The framework on which the quarters hung was detachable from the trolley, and it was removed by the ship's derricks direct to a platform erected on the square of the hatch outside the special chamber. A loose canvas cover hung over the framework, protecting the beef from solar radiation and (if necessary) rain.

The time occupied between the transfer from the air lock and stowage in the ship varied from ten to fifteen minutes. The short exposure to the external atmosphere, the ideal weather conditions prevailing, and the relatively dry superficial tissues of the beef prevented any marked "sweating."

6. Stowage.

Three days prior to the commencement of loading, the ship's "gas-tight" chamber was sterilized with gaseous formaldehyde.

Owing to lack of experience by the wharf labourers, stowage proceeded very slowly, and the beef required to fill the chamber (44 tons) took some six and a half hours to place in position. All quarters were hung from meat rails running fore and aft. The hindquarters were hung low on chains with the rib (lower) ends from 6 to 12 inches from the deck, and the crops were hung high direct to hooks in each alternate space between the shanks of the hindquarters. The areas of contact between the hindquarters were the fat close to the aitch bone and the connective tissue on the rump, while the cut edges of the lowest rib of the crops were in contact with shanks of the hindquarters. While the stowage was relatively tight, it was easily possible to insert the hand between the areas of contact between the quarters. Into the free air space of 5,250 cubic feet, 404 hindquarters and 200 crops, weighing slightly more than 44 tons, were stowed, and this was equivalent to 1 ton of meat occupying 119 cubic feet of free air space. It is understood that this is the closest stowage which has been obtained so far in shipments of chilled beef from Australia.

Immediately after stowage had been completed, the doors of the chamber were sealed, and carbon dioxide to the extent of 11 per cent. was introduced.

7. Losses of Weight of Beef.

The average loss of weight of the sides from slaughter to cutting down—72 hours approximately—was 2.2 per cent.

In order to determine the losses of weight of the quarters during the voyage to London, permission was obtained from two exporters to place special identification marks and appropriate numerals on the outer wraps of a number of hindquarters and crops which were carefully weighed prior to despatch to the ship. Arrangements were made for these quarters to be weighed again at the ship's side on discharge of the beef in London.

8. Microbial Counts.

Determinations were made of the extent of the microbial contamination of the exposed fat and muscle from various areas of twenty sides immediately post-slaughter and from twelve sides after the completion of chilling in the abattoir. The samples so taken were incubated at temperatures of 20°C. (68°F.) and −1°C. (30.2°F.). Since only the "low temperature type" micro-organisms are of significance, from the point of view of the possible duration of storage of the beef, the counts of the samples incubated at 20°C. (68°F.) need not be given.

Immediately post-slaughter, the "low temperature type" count on the exposed muscle ranged from 3 to 40 organisms per square centimetre. These consisted of very slow growing *Achromobacter* and yeasts; the number of moulds was considerably less than one per sq. cm. At the completion of chilling in the abattoir, the counts on the exposed muscle of the crops (neck areas) averaged 110 per sq. cm. and on the hindquarters ranged from 8 to 10 per sq. cm. The average count on the exposed fat and connective tissue was 300 per sq. cm.

The types of organisms were similar to those found on the beef immediately post-slaughter. Judged from previous experimental work, these counts are sufficiently low to ensure that the beef may be stored safely for a period somewhat in excess of 50 days.

Owing to the extensive variation of counts from day to day, one series of experiments does not establish the efficacy of the modified technique employed in the preparation of the beef. It has been possible, however, to study both the old and the new technique over a period of several weeks, and the average value of a large number of counts indicates that the use of the new technique results in the reduction of the contamination to approximately one-seventh of its former average. The added margin of safety for the storage of chilled beef so gained is, therefore, considerable.

9. Physical Data Obtained During Voyage.

The Council's officer* who travelled to London with the shipment obtained general data regarding temperatures of the air and meat in the "gas-tight" chamber, as well as the relative humidity, rate of movement, and composition of the storage atmosphere. Particular attention was also paid to the fluctuations in the concentration of carbon dioxide according to the extent of the pitch and roll of the vessel and the prevailing sea and wind.

At this juncture, it is impossible to give particulars concerning either the mode of construction and refrigeration of the "gas-tight" chamber or the physical conditions obtaining during the voyage. The conditions aimed at, however, were the maintenance of an air temperature of $-1.4°C.$ (29.5°F.) and an atmosphere containing 11 per cent. carbon dioxide, while the rate of forced air movement was to be regulated according to the relative humidity prevailing in the storage atmosphere.

10. Condition of the Beef in London.

The beef was placed on the wholesale market in London 44 days after slaughter at the abattoir, the duration of the voyage from Brisbane being 39 days.

Advice received from the Council's officer, by cablegram, indicated that the beef arrived in excellent condition. No visible bacterial, fungal, or yeast growth could be detected on the quarters examined, and the "bloom" of the beef had not undergone any appreciable deterioration.

11. Conclusion.

It is as well to emphasize that all phases of the experiment, with the exception of the stowage, were carried out under strictly commercial conditions, particularly from the point of view of speed. During the slaughter and dressing of the beef in the abattoir, despite the more complex procedure adopted and the fact that the number of butchers employed did not exceed the normal figure, the normal rate of slaughter of the cattle was maintained; interference with this rate is serious in any meatworks, for the economical operation of the whole plant is largely dependent upon its maintenance.

* Mr. N. E. Holmes.

Caseous Lymphadenitis—Factors Associated with its Spread under Natural Conditions.

By L. B. Bull, D.V.Sc., and C. G. Dickinson, B.V.Sc.†*

Investigations into the difficult caseous lymphadenitis (cheesy gland) problem form an important part of the activities of the Council's Division of Animal Health in so far as its work on sheep diseases is concerned. In addition other organizations and their veterinary officers have undertaken to investigate certain aspects of the problems as part of the general scheme of attack. The work described in the article that follows falls within the last-mentioned category, having been undertaken by Dr. Bull and Mr. Dickinson when the former was at the Laboratory of Pathology and Bacteriology, Adelaide Hospital, as Director. The authorities of that hospital have agreed to continue to afford laboratory and other facilities for the work, although Dr. Bull has now joined the Council's staff.—Ed.

Summary.

Preisz-Nocard bacilli have been demonstrated in the soils from sheep camping grounds when the climatic conditions were favorable. They could not be recovered from the same camps after they had been subjected to the heat of a South Australian summer or after a severe frosty winter. We have not been able to recover the organisms from the soils of the open paddock, or from that from sheep-yards or counting-out pens.

Treating the soil with sulphur renders it more acid, and consequently less favorable for the continued existence of the Preisz-Nocard bacilli in it.

The organisms have also been recovered from the faeces of sheep infected with caseous lymphadenitis, and also from those of sheep without lesions of the disease.

Certain suggested measures for the prevention of the disease are given.

1. Introduction.

Woodruff and Gregory (1920), Seddon (1929), and Seddon, Belschner, Rose, and Blumer (1929) came to the conclusion that sheep are commonly infected with caseous lymphadenitis in the shearing sheds. It was determined that in an infected flock a certain number of animals will show, at any time, either discharging lesions or lesions that have recently been discharging. The assumption was that the discharges from such lesions, or from lesions actually ruptured on the shearing boards, contaminated the head pieces, and that these last then carried the infection to other sheep which were wounded in the process of being shorn.

Later, Seddon and Belschner (1932) concluded from their observations that infection most commonly takes place in the counting-out pens and yards rather than on the shearing boards. The infecting material was assumed to be the dust of the pens and yards which would fall on to the wounds made in the shearing shed. Carne (1932) considered the possibility of infection resulting from contamination of wounds by sheep droppings, although he had no definite evidence that the Preisz-Nocard bacillus could be found in them under natural conditions.

Dayus and Hopkirk (1932, 1933) have also come to the conclusion that infection takes place in the shearing shed through the transfer of pus from discharging lesions to the fresh wounds by means of the head

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pieces of the shearing machines. Taking this as a basis for measures of control, they have manually examined several flocks and culled those animals showing enlarged superficial glands, as well as instituting all hygienic precautions in the shearing sheds. They report a very decided fall in the incidence of infection following the institution of these methods. In one flock of ewes, containing 11,196 animals, the incidence has been reduced from 9.34 per cent. to 1.85 per cent. in two years. They claim that these results support their hypothesis of infection in the shearing shed.

The present report deals with an extension of observations recorded previously, Bull and Dickinson (1933).

2. Observations on a Property in South Australia.

We have had the opportunity of making some observations on the spread and extent of infection in a stud flock of a British breed on a property north-east of Adelaide, where the disease is enzootic.

This property has been used for sheep, mainly Merinos, for the last eighty years or more, but it is not possible to obtain any history bearing on the subject of caseous lymphadenitis in animals kept there prior to our personal observations. In 1928, the present owner started a stud of a well-known British breed. In 1931, two sheep from this property were brought to the laboratory for investigation. Both were affected with caseous lymphadenitis. This was the first time the disease had been diagnosed in this stud, although the owner knew that the sheep occasionally suffered from "boils." A stud ram was imported from England early in 1931, and about the middle of the year, it showed a swelling in the region of the prescapular lymph gland which proved to be an abscess due to *Corynebacterium pyogenes*. In November of the same year, the animal developed three subcutaneous nodules in the perineum. These were removed surgically, and a pure culture of the Preisz-Nocard bacillus was obtained from them. In March, 1933, the animal had developed another lesion in the breech and several in the scrotum.

In April, 1932, we examined a cow with a wound in the foreleg, and a large prescapular abscess due to an infection by the Preisz-Nocard bacillus. This animal had been grazing on the property for about three months, and it had become wounded and infected.

During the 1932 season, some crossbred lambs from this property were sent to the killing works for export, where 11.7 per cent. were found affected with caseous lymphadenitis.

We had not examined many of the animals on the property, at this time, but the owner quickly made himself familiar with the methods of manual examination and detected a number of affected animals in the stud. Several rams, none of which had ever been shorn in a shearing shed, were found to be affected. The ewes had been hand-shorn in the shearing sheds, which were thoroughly cleaned and sprayed with a disinfectant before and during shearing operations, the same treatment being given to the counting-out pens, which are paved with concrete.

In March, 1932, there were 282 stud animals. Of these, 29 ewes and six rams were apparently affected. Of the 282 animals, 104 were lambs. Disregarding the lambs, there were 35 apparently affected animals out of a total of 178, which represents 19.6 per cent. A large proportion of the animals were showing, or had shown, discharging lesions in the superficial lymph glands, the precrural being the most frequently affected. Two of the rams showed well-developed lesions in

the scrotum. The lesions in one of them were opened surgically and the Preisz-Nocard bacillus cultivated from the material obtained.

A consideration of these facts led us to suspect that the animals on this property were probably being infected in the paddocks. The cow, the crossbred lambs, and the rams had never been inside a shearing shed. The ram imported from England had become infected within eight months. The cross-bred lambs had been carefully marked with instruments kept in a solution of lysol, and then placed over the fence of the marking yard straight into the paddock. The lambs from one paddock were more heavily infected than those from another, there being an incidence of 20 per cent. in the one case as against 3 per cent. in the other. We therefore examined soil from several of the paddocks for the presence of the Preisz-Nocard bacillus.

The method of testing soil and other material for the presence of the Preisz-Nocard bacillus has already been described by us (1933).

3. Examination of Soil Samples.

In October, 1932, while the soil was still moist, six samples were collected. Four of the samples were from the paddocks, mainly from areas used by the sheep as camping grounds. The two other samples were from the marking yards and the sheep yards respectively. Two guinea-pigs were used for testing each sample.

Three of the four soil samples from the camping grounds produced Preisz-Nocard infection in the guinea-pigs. We obtained no evidence of infection in the soil from the marking yards and the sheep yards. All the samples giving negative results were re-tested five weeks after the original test, with the same result.

About the middle of February, 1933, further soil samples were examined from this property. Soil was taken from the same four paddocks as in the original test and, in addition, from two paddocks not previously examined. The weather had become warm and dry, although the summer, as summers go in these parts, was a cool one. The soil samples were quite dry and the soil had been dry since the previous November. A positive result was obtained from only one of the samples, that from paddock T, both guinea-pigs developing characteristic lesions. The camping grounds in paddock T are somewhat different from those in the other paddocks and deserve special mention. It has an area of 11 acres and a plantation of pine trees along one side. The branches of these trees come very close to the ground and the shade is very dense, scarcely any sunlight reaching the ground, which is still further protected by the fallen pine needles. Under these conditions, the soil retains a certain amount of moisture, and it is not subjected to the drying effects of direct sunlight and a free circulation of air. This paddock T also has a hawthorn hedge through which the animals used to wander, two large gum trees under which the animals also camped, and other trees.

In two other paddocks, the main sheep camps are under pine trees, but these are more exposed and subject to the drying effect of sun and wind. The remaining camps are all under large gum trees, which do not throw such a dense shade.

Further samples of soil from the camping grounds were collected at the end of March, 1933, and all gave negative results.

Samples were again collected in June, July, September, October, and December. In all, 57 samples of soil were examined during this time. In June, the Preisz-Nocard bacillus was demonstrated in a

sample from paddock T under the pines, and from two contiguous camps under gum trees in paddock S, used for affected sheep, and in which the cow had become infected.

The winter of 1932 was wet and mild. The first samples of soil collected in October, 1932, were still moist from the winter and spring rains. Following these, the soil rapidly became dry and remained dry until April, 1933, when good falls of rain occurred. During the dry period, we were unable to demonstrate the Preisz-Nocard bacillus in any of the soil samples (except that from paddock T), many of which were taken from camping grounds previously shown to be heavily contaminated with the bacillus. In early June, 1933, we did find the bacillus in 3 samples out of 10 collected. The winter developed into a very cold and dry one with heavy frosts almost daily. These conditions extended into November, when some hot days occurred, but were interspersed with cold frosty days. Under these conditions, which differed entirely from those obtaining during the previous year, the Preisz-Nocard bacillus, after a fleeting appearance in June, disappeared, and has not re-appeared in the soil up to the present time (February, 1934).

The results of these observations seem to indicate that the Preisz-Nocard bacillus does grow in the soil of these camping grounds when moisture and temperature are favorable. The bacilli did re-appear after the hot and dry weather in some of the camping grounds early in June, after the early rains and before the soil had become too cold. The excessive and continuous cold, however, was probably responsible for their subsequent disappearance. We can anticipate that during the dry months of the year it will not be possible to demonstrate the presence of the bacilli, but regular examination of the soils must be continued if we are to come to an understanding of the factors responsible for their presence and their disappearance.

As it was believed that the existence of the Preisz-Nocard bacillus in the soil of the camping grounds was responsible for the infection of the lambs at marking time, and also some of the adult sheep, it was decided to attempt to render conditions unfavorable for the growth and continued existence of the bacilli in the soil. Under artificial conditions, the bacillus is adversely affected by acidity of the medium in which it is present. We therefore decided to render the soil acid by applying finely ground sulphur to the camping grounds at the rate of ½ ton to the acre. This procedure proved successful. For example, one soil showed an original pH 7.20; a fortnight after the application of sulphur it showed a reaction pH 6.0, and at two months showed pH 5.5, which fell to pH 5.2 at the end of approximately five months. The final reactions of the soil from the various areas treated ranged between pH 5.2 and pH 4.2, and the fall was more rapid in some cases where the application was followed by good rains.

4. Examination of Faeces from Sheep.

We have been unable to demonstrate the Preisz-Nocard bacillus in the soil from the open paddock, and it was thought that the accumulation of droppings in the camping grounds might account for the presence of the bacilli in the soil in these situations. Examinations of sheep faeces have, therefore, been carried out, and the Preisz-Nocard bacillus has been demonstrated to be a common inhabitant of the digestive canal of sheep.

Some of these tests have been carried out on faeces collected from animals known to be affected with caseous lymphadenitis. Of 20 samples from such animals, 11 have shown the presence of the Preisz-Nocard bacillus. All these samples were from animals that had been on the property mentioned above. Other samples examined were from sheep on the same property, but were found to be free from caseous lymphadenitis on post-portem examination. Of 16 such samples examined, the Preisz-Nocard bacillus has been demonstrated in two.

Amongst the animals from which samples of faeces were collected, 14 were ration sheep that had been on the property for comparatively short periods. Only one positive sample, and that from an animal showing no lesions, was obtained from these sheep. All of the other samples were from 13 stud sheep, and these have been killed and examined except in two instances. In 4 of the 13, positive results were obtained from two animals showing lesions in the lungs, so that, in these cases, the presence of the bacilli might possibly be explained by the swallowing of infected material.

Some of the animals were tested more than once, and samples of faeces have been kept at 22°C. for approximately three weeks and re-tested in many instances. In some cases, a negative result has been obtained on examination of the fresh specimen, but after keeping the specimen for three weeks at 22°C. a positive result has been obtained. We have also observed that a fresh specimen may give a positive result followed by a negative result after the specimen has been kept for three weeks.

An experiment was conducted to determine if the Preisz-Nocard bacillus could establish itself in the alimentary canal of sheep following drenching of infective material. Two lambs, about two months old, were selected. The faeces of the animals were tested twice, with an interval of a month, before the animals were placed in a pen. Both these tests failed to demonstrate the presence of the Preisz-Nocard bacillus. The animals were placed in a pen and hand-fed. Two samples of faeces were collected with an interval of two days between collection. These samples were also kept for three weeks and again tested. All tests gave negative results.

The lambs were then drenched with 10 gm. of pus, from natural lesions of caseous lymphadenitis, in 50 c.c. saline. Samples of faeces were collected 2, 3, 5, 7, 14, 21, and 55 days after the drenching. The animals were then turned on to grass for 16 days, and samples collected on 3 successive days. All these samples were kept for three weeks and re-tested.

The Preisz-Nocard bacillus was demonstrated in the fresh specimen from one lamb 5 days after drenching. The fresh samples from both lambs collected 14 days after drenching gave negative results, but after keeping them for 3 weeks and re-testing, the Preisz-Nocard bacillus was demonstrated in each case. All the other tests yielded negative results.

It would appear from the results of this test that the Preisz-Nocard bacillus does not always become easily demonstrable in the faeces or droppings of animals that have been drenched with infective material. It would appear further that the bacillus did establish itself in the alimentary canal of these animals, although it did not occur in the faeces in large enough numbers to be demonstrable on all occasions by the method used. On the other hand, it is possible that the bacillus

was in the alimentary canal of these animals before they were drenched, and the larger number of examinations made subsequent to the drenching might be responsible for their successful demonstration in three samples, that is, in three tests out of thirty-two.

5. Significance of Personal Observations.

On the property that we have had under study, there is no doubt that at least some animals have become infected with the Preisz-Nocard bacillus and have developed lesions of caseous lymphadenitis under such circumstances that infection in the shearing-shed can be definitely excluded.

The Preisz-Nocard bacillus is to be found in the environment of the sheep. We have demonstrated it in the discharges from lesions, on the surface of the body of sheep having lesions of the disease, in the droppings or faeces of sheep both with and without lesions of the disease, and in the soil in sheltered areas used by sheep for camping during the heat of the day.

We have failed to demonstrate the bacillus in the discharges of lesions that have become dry, in the soil from camping grounds when it has become dry, and in the soil from sheep yards at any time. Both Carne (1933) and Murnane (1933) have failed to demonstrate the bacillus in the dried faeces or dust of sheep yards and counting-out pens. These observations, which are supported by those carried out under controlled laboratory conditions, indicate that the bacillus is killed very readily by drying. It would appear improbable, therefore, that live Preisz-Nocard bacilli are ever to be found in dust.

During the 1933 season, no cross-bred lambs became affected on the property under study, although up to 20 per cent. became affected the previous year. Precautions against infection were taken in some of these lambs by the use of the Burdizzo emasculator, but others were left in paddocks where the camping grounds were not treated with sulphur and no precautions of any sort were taken. If the cross-bred lambs in 1932 became infected in the camping grounds, and if this is a common method of infection of freshly marked lambs, then it is not remarkable that no lambs became infected in 1933 when we were unable to demonstrate the bacillus in the soil.

We believe that the presence of the bacilli in the soil of the camping grounds is likely to cause infection of wounds however these are made. Animals coming from a shearing shed with numerous wounds are likely to have those wounds infected when resting on these camping grounds. It seems probable that infection commonly takes place in this way. We know of one property where the wethers have always been shorn in March while the ewes have been shorn in September. The wethers have been sent to slaughter at from two to three years of age, and have shown an appreciable incidence of caseous lymphadenitis in spite of the fact that they have never been through the shed with older animals which might have discharging lesions. These wethers could not have become infected by contamination of wounds with discharges in the shearing shed.

The bacillus is present in the digestive canal of some animals, and it is possible that wounds may become infected by contact with the droppings from such animals. This might possibly take place in

counting-out pens or in holding-yards, but we have no evidence indicating that infection can be caused by dust in these pens and yards. If infection does not take place in the pens and yards, it may take place in the camping grounds. Conditions in these camping grounds would not always be favorable to infection, and this may be the explanation of the seasonal variation in the incidence of the disease that we commonly find.

The origin of the Preisz-Nocard bacillus in the soil of the camping grounds has not definitely been established. Observations that are being made should help to solve this problem. We know that the bacilli may be present in the droppings of sheep. We also know that the bacilli may increase in numbers in the droppings provided sufficient moisture is present. It is possible that the Preisz-Nocard bacilli grow out from the droppings into the soil where conditions may be more favorable for their growth and multiplication. This would appear to be the most probable explanation of the presence of the bacilli in the soil of camping grounds. However, the bacillus may be a soil bacterium, and it may possibly be found normally in certain types of soil under certain conditions, without association with the sheep. It is also possible that it may be found in the digestive canal of animals other than the sheep, and that the droppings of these animals may also be responsible for its distribution in soil.

Our observations have shown that the Preisz-Nocard bacillus is not an obligatory parasite, but more work will have to be done before we can determine its natural habitat. This problem is receiving attention.

6. General Discussion.

Evidence is accumulating in Australia indicating that the institution of all hygienic precautions against infection by the Preisz-Nocard bacillus of sheep in shearing sheds is not successful in preventing the development of caseous lymphadenitis, although the incidence may be appreciably reduced.

As the result of observations made over a period of three years, Seddon and Belschner (1932) concluded that infection took place in the counting-out pens rather than on the shearing boards. The number of animals used in their experiments was rather small, but the observations are of interest and importance. However, we cannot agree that infection with the Preisz-Nocard bacillus is caused by contamination of wounds with dust.

Dayus and Hopkirk (1932, 1933) based their preventive measures on the hypothesis of Woodruff and Gregory that infection takes place in the shearing shed. By instituting all hygienic precautions in the shearing shed and by culling, or eliminating from the flock, all animals possessing palpably enlarged superficial lymph glands, they reduced the incidence of affected animals from 9.34 per cent. to 1.85 per cent. in two years in one ewe flock. In another flock, the incidence was reduced from 3.32 per cent. to 2.77 per cent. in one year. In a wether flock, the incidence was reduced from 8.01 per cent. to 3.16 per cent. in one year.

We have examined their figures to determine if any indication is given of the common method of infection. We find that in the first ewe flock the incidence in two-tooths (yearlings) was reduced from 1.01 per cent. to 0.25 per cent., a reduction of 75 per cent. In the

groups of older animals in this flock, the reduction was between 82 per cent. and 87 per cent. In the North Island flock, where the youngest animals examined were four-tooths, the change in incidence was from 0.44 per cent. to 1.08 per cent., which represents an increase of 145 per cent. in this group, while the six-tooths, eight-tooths, and full-mouth animals showed 11 per cent., 13 per cent., and 24 per cent. reductions in incidence respectively.

On the assumption that the main infection takes place as suggested by Woodruff and Gregory, when all palpably affected animals are eliminated from the flock and no animals with discharging lesions go through the shearing shed, it is anticipated that no further animals will become infected, but occult lesions may become manifest in older animals for some time. Even if this anticipated result is not obtained, there should, at least, be a greater fall in the incidence of infection in the younger groups. This anticipated result has not been obtained by Dayus and Hopkirk, in fact the proportion of infected two-tooths to full-mouths in the first ewe flock rose from 1 : 23 in the year 1931 to 1 : 16 in 1933. In all the other groups in the three flocks of which they supply figures, this same relative rise in incidence in younger groups of animals is exhibited.

We cannot agree with them that their results support the hypothesis that caseous lymphadenitis is mainly due to infection taking place in the shearing shed. It is difficult or impossible for us to draw definite conclusions from their results as there are probably several unknown factors. They state that the use of No. 2 combs, one of the alterations made in the shearing methods, considerably reduced the number of cuts and abrasions. This, in itself, might have been responsible for the general decrease in incidence of infection, irrespective of where the infection was contracted. They eliminated from the flock many of the susceptible animals, and this also might have altered the incidence of infection.

Our experimental evidence suggests that older animals are more susceptible to infection than younger animals. If a clean flock is obtained by the elimination of manifestly infected animals, infection will not take place from animal to animal in the shearing shed, but all wounded animals will have an approximately equal chance of becoming infected elsewhere, such as in camping grounds under conditions favorable to the growth and viability of the Preisz-Nocard bacillus. Under these conditions, we would expect the incidence of infection to become more equally distributed in the different age groups. There would still be a tendency for older animals to show a higher incidence of infection, firstly on account of increased susceptibility, and secondly on account of the enlargement of lesions that were too small to be detected previously by palpation.

We are forced to conclude, therefore, that the results of Dayus and Hopkirk do not add evidence in favour of the hypothesis advanced by Woodruff and Gregory. The evidence, however, is not inconsistent with the assumption that wounded sheep are liable to pick up infection in camping grounds and possibly other situations contaminated by sheep faeces.

The results of Dayus and Hopkirk show that the preventive measures used by them reduce the incidence of the disease in a flock, but the reduction may be as low as 13 per cent., as in their North Island flock of 19,000 animals, in spite of the fact that over 500 animals had been culled in each examination.

The elimination of the infected animal from the flock appears to be wise, for not only may the animal contaminate its environment by discharges from lesions, but results of our investigations indicate that the digestive canal of the infected animal is more likely to harbour the Preisz-Nocard bacillus than that of the non-infected animal. It is possible that the bacillus may be more widely spread by the droppings of animals than by discharges from lesions.

7. Preventive Measures.

As a result of general experience and of our own observations, we would suggest the following preventive measures:—

1. The elimination from the flock of animals proved by palpation to be affected.
2. The employment of hygienic methods in the shearing sheds.
3. The elimination, if possible, of counting-out pens and holding-yards.
4. The provision of a clean paddock for the reception of all animals off shears. This may be provided for in some parts by turning the animals on to a crop for a few days. In other parts, it means the provision of a paddock containing sufficient feed to maintain the animals for a period of from three to seven days. This paddock must be kept free of sheep for several months immediately before shearing operations commence, particularly during the wet months. If these conditions cannot be met, in order to make the soil unfavorable for the growth of the Preisz-Nocard bacillus, the camping grounds should be treated with ground sulphur at the rate of half a ton to the acre, applied during or just before the wet season. The alteration in the reaction of the soil produced by a single application of sulphur will last for several years.
5. At all times, care should be taken not to injure or wound the skin of the sheep. Wounds should be treated with some protective material, such as Stockholm tar, in preference to watery solutions of common disinfectants which offer no protection to the wound from subsequent contamination.

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The Root Distribution of Some Agricultural Plants.

*By Eric S. West, B.Sc., M.S.**

Summary.

The results of examinations of the root zones of lucerne, wheat, beans, rice, and citrus are discussed.

With the exception of citrus, the greatest concentration of the roots was found to be right at the surface. In the case of citrus, the cultivation of the soil prevented this.

The practice of deep and excessive tillage of the soil, when plants are growing in it, as in orchards, is questioned.

1. Introduction.

In any question which concerns the growth of higher plants, a difficulty is always encountered when consideration is given to that important part of the plant within the soil, viz., the root system, as we cannot see the roots and can usually only guess what the root system is like.

In this paper, some observations of the root distribution of a few agricultural plants, gathered in the course of studies concerning the moisture content of soils in which plants were growing, are described and briefly discussed.

2. Methods.

The root zone was investigated by taking borings by means of a Veihmeyer soil tube, which removes a core of soil 1 inch in diameter. Samples were usually taken in depth increments of 10 cm.; but the inclusion of parts of two soil horizons in one increment was avoided. The samples were soaked in water to soften the soil and washed on a sieve with a stream of running water. The pieces of roots were removed and dried. When dry, the last adhering traces of soil could be easily removed and the roots were then weighed. Six replicate borings were usually sufficient to remove sampling errors.

As the object was to obtain an idea, not only of the depth of the root penetration, but also the relative absorbing area of the roots, only root fragments which may be considered important from this point of view were used. Thus, if the core of soil happened to contain a portion of a large main root, for obvious reasons it would not be included.

With most plants, the demarcation between the fine rootlets mainly concerned in absorption and the larger roots is distinct. Thus, in the case of citrus, the absorbing rootlets are a distinct branching ramification of roots of uniform diameter without root hairs, but with which are associated an endophytic mycorrhiza; while, in the case of wheat and rice, all roots can be taken as being concerned in absorption.

By this method, it is possible, not only to determine very readily the extreme limit of the root zone, but also to obtain a numerical factor to indicate the relative root concentration in successive layers of soil, or in other words the relative root absorbing area. In Fig. 1, the root

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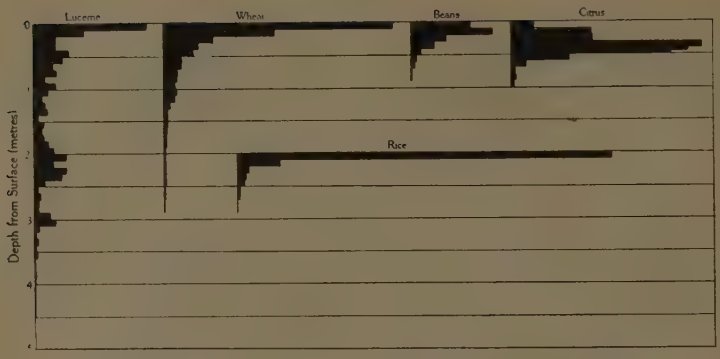

FIG. 1.—Root concentrations of plants at different soil depths.

concentration is shown for the various plants along the horizontal axes in milligrams of dried rootlets per 10 cm. of soil core of 1 inch diameter.

One cannot, of course, press comparisons between the root concentrations of plants of different species too far in this way, as there is no reason to suppose that a certain weight of citrus rootlets, for example, has the same absorbing power as an equal weight of wheat rootlets. Wheat rootlets are of smaller diameter than citrus rootlets, and, while absorption is presumably through the hypha of the mycorrhiza in the case of citrus, in wheat it is through root hairs. The figures do, however, show the relative concentration of the absorbing roots with depth for any particular plant.

3. Results.

The following table shows the percentage distribution of the roots of the plants studied with depth:—

Depth in cm.	Lucerne.		Wheat.		Beans.		Citrus.		Rice.	
0– 10 ..	16·6		31·2		27·0		3·8		82·0	
10– 20 ..	7·5		15·0		37·6		12·8		10·1	
20– 30 ..	3·4		10·4		17·0		13·0		2·6	
30– 40 ..	3·1		7·2		8·5		29·9		2·0	
40– 50 ..	5·2	51·7	6·2	85·7	5·0	100·1	26·4	100·0	1·7	100·0
50– 60 ..	4·4		3·9		2·3		9·2		0·7	
60– 70 ..	2 9		3·7		1·9		2·6		0·7	
70– 80 ..	3·5		2·9		·7		·7		·1	
80– 90 ..	1·8		2·8		·1		1·0		·1	
90–100 ..	3·3		2·4		..		·6		..	
100–110 ..	2·2		2·8							
110–120 ..	1·3		2·3							
120–130 ..	1·7		1·3							
130–140 ..	2·1		·9							
140–150 ..	·7	17·3	·9	11·6						
150–160 ..	1·5		·9							
160–170 ..	1·1		·8							
170–180 ..	1·5		·6							
180–190 ..	2·1		·6							
190–200 ..	3·1		·5							

Depth in cm.	Lucerne.		Wheat.		Beans.	Citrus.	Rice.
200–210 ..	4·9		·3				
210–220 ..	2·9		·3				
220–230 ..	5·0		·4				
230–240 ..	4·1		·5				
240–250 ..	1·6	24·0	·5	2·7			
250–260 ..	·7		·3				
260–270 ..	1·0		·2				
270–280 ..	·8		·1				
280–290 ..	·7		·1				
290–300 ..	2·3		..				
300–310 ..	3·2						
310–320 ..	·9						
320–330 ..	·2						
330–340 ..	·6						
340–350 ..	·3	6·3					
350–360 ..	·4						
360–370 ..	·1						
370–380 ..	·1						
380–390 ..	·3						
390–400 ..	·2						
400–410 ..	·1						
410–420 ..	·2						
420–430 ..	·1	·7					
430–440 ..	·2						
440–450 ..	·1						

Referring to Fig. 1, it is seen that different plants have very different types of root systems. With the notable exception of citrus, however, the root systems all have one characteristic in common, and that is great concentration of roots very close to the surface. The significance of this is discussed later.

Lucerne: The soil in which the lucerne was growing is a medium loam to 20 cm., below which it is clay.*

The most striking characteristic about the lucerne root system is the well known habit of deep penetration. The rather irregular outline of the graph is due to the large variability of the root concentration of lucerne in this type of soil, which is readily seen when the root system is examined in a trench. There is a tendency for the roots to be crowded into the cracks and small channels of the soil, where presumably root elongation and thickening is easier and aeration is better. The two apparent maxima at approximately the 230 cm. and 300 cm. depths are due entirely to the sampling error. It so happened that at these depths one or two samples contained excessively large weights of roots and the number of replications was not great enough to smooth out the irregularities.

The deep root system of lucerne, of course, permits the plant to survive long periods of drought, as it can effectively dry out the soil to great depths†. Notwithstanding the very thorough occupation of the soil to such great depths by the lucerne plant, even in this case by far the greatest concentration of roots is right at the surface, the portion of the soil which is best aerated and where, incidentally, the superphosphate which is so essential to the growth of the plant is placed.

* For a full description of this soil, see West, E. S., "Observations on Soil Moisture and Water Tables in an Irrigated Soil at Griffith, N.S.W." Coun. Sci. Ind. Res., Bull. 74, 1933.

† West, E. S., ibid.

Wheat: The samplings for the wheat roots were taken when the grain was in the soft dough stage. The land had been fallowed but had not been irrigated. The soil was a mallee soil, with a fairly light surface soil, but moderately heavy sub-soil.

The root zone is characterized by a gradual decrease in concentration with depth. Although the extreme root penetration is nearly 3 metres, the concentration in the third metre is so small as to probably be of little significance. However, the second metre contains about 10 per cent. of the roots, so that, compared with such plants as citrus and tick beans, the wheat is deep rooted, which fact probably plays some part in its drought resistant properties.

Tick beans (Vicia faba): The tick bean soil is similar to that in which the lucerne was growing.

The great bulk of the roots are confined to the top 50 cm. of soil. These plants cannot tolerate dry soil conditions and are among the first to wilt. Probably, within the root zone the soil is only poorly explored with roots, as beans will wilt when the surface soil quite close to the plants is moderately moist. Notwithstanding this, they intercept moisture added by the winter rains, and are, therefore, valuable in the orchard during wet winters, checking water logging to an appreciable extent.*

Rice: The rice soil was the grey crab-holey soil, typical of the rice land of the Murrumbidgee Irrigation Areas. The striking feature of the root zone of the rice is its shallow nature, 82 per cent. of the roots being within 10 cm. of the surface. The roots of the rice plant form a close mat near the surface. This is, without doubt, connected with the very special condition of growth of the rice, inasmuch as during its growth the soil is inundated with water to a depth of a few inches. Incidentally, it is this dense mat of roots that prevents the puddling of the wet clayey soil by the trampling of horses and implements during harvesting operations. This fortunate effect preserves the texture of the soil and thus permits the continued cultivation of paddy lands.

Citrus: The soil of the citrus grove where this sampling was done was a sandy loam to 45 cm., below which was a light clay.†

The root zone is largely confined to the top 60 cm. of soil.‡ The important thing about the citrus root zone is the comparative absence of roots in the surface soil, although, in the other plants studied, this part of the soil contained the greatest concentration. The reason for this is, of course, that the cultivation of the citrus soil prevents the formation of the roots near the surface. It is apparent that a deep ploughing under these conditions would do considerable damage, particularly as some large roots are situated rather close to the 10 cm. level.

An examination was also made of the roots of citrus trees growing on heavy crab-holey soil, similar to the rice soil. In this case, the roots were examined by opening up a trench, and tracing out individual roots. This method is very tedious and takes two or three weeks to examine a small section of root zone. Fig. 2 illustrates the extent and ramification of one main root down to fairly small subdivisions. It must be remembered, of course, that very many branches of other roots also occurred

* For a full description of this soil, see West, E. S., "Observations on Soil Moisture and Water Tables in an Irrigated Soil at Griffith, N.S.W.," Coun. Sci. Ind. Res., Bull. 74, 1933.

† West, E. S., Ibid.

‡ The trees were on rough lemon stock.

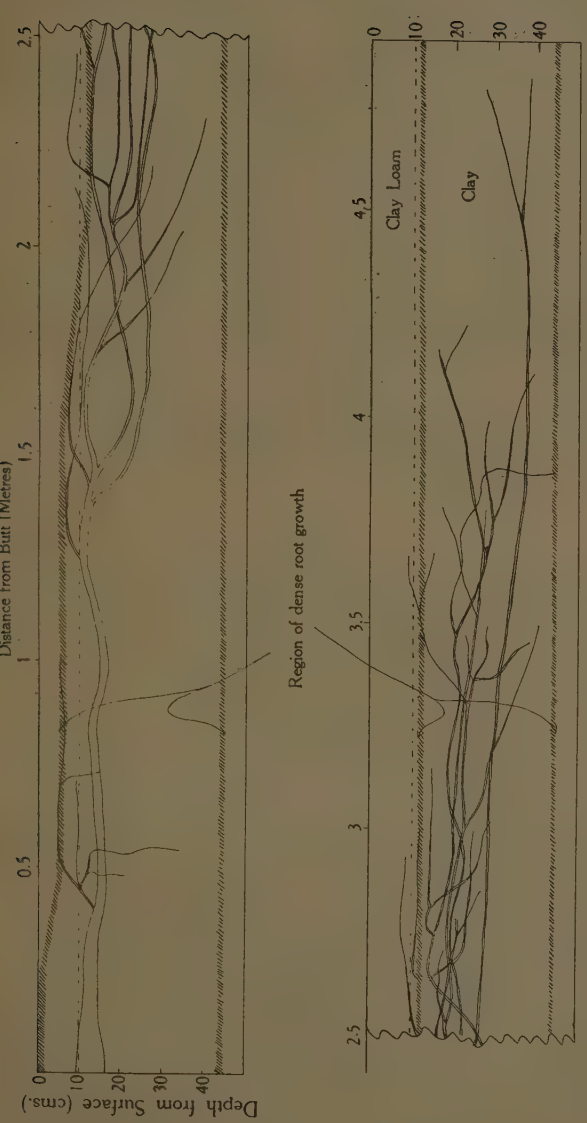

FIG. 2.—Root distribution of citrus in heavy soil showing major ramifications of one root, and region of dense root growth.

in this section, but to show them makes the diagram too complicated. It was found that a well defined zone of the soil contained a very complete network of the fine reticulating rootlets of citrus. This zone is shown by marginal shading.

The surface 10 cm. of soil was a clay loam, below which was a heavy clay. The change in the profile is indicated by a broken line. The trees in this orchard are planted 22 feet apart, and the section here shown extends from the butt of the tree to the centre of the square between four adjacent trees, a distance of 15 ft. 6 in., or 4.75 metres.

It is seen that in the cultivated portion of the soil the soil is thoroughly occupied by roots from the depth of cultivation, 10 cm., to 45 cm. Under the foliage (from the butt to a distance of 1.9 metres), the root zone approaches closer to the surface.

A few stray roots* following down cracks or channels left by roots of the native flora penetrated below the general root zone to as deep as 80 cm. Such roots, however, represented an infinitesimal part of the whole root zone, and their influence would be quite negligible.

As the whole of the soils from one tree trunk to the next was uniformly occupied by roots, the limiting factor to the tree size is the soil available. Practical experience shows that, within limits, the sizes of the trees, when mature, bear an inverse relationship to the spacing, so that the total volume of the trees per acre is more or less constant.

4. Discussion.

It is apparent that there is a general tendency for plants growing in uncultivated soil to develop their roots in the greatest concentration very near the surface of the soil. It is here that the soil is best aerated, and perhaps the mineral nutrients of the soil are more readily available. In semi-arid climates, where the transpiration of the plants exceeds the rainfall, many showers do not wet the soil more than a few inches. Under such conditions, a large concentration of absorbing roots near the surface would make use of much rain that would be lost to the plants were the bulk of roots situated at a lower depth.

It is often assumed that surface rooting is a bad thing. The surface of the soil is subject to great temperature and moisture changes and, so it is argued, should be a bad place for roots. Deep cultivation is a remedy sometimes suggested. However, the fact that the habit of producing a large concentration of roots near the surface is so general, suggests that for some reason it is for the benefit of the plant to develop roots near the surface. One might, therefore, question whether deep cultivation of the soil, when plants are growing in the soil, is a good thing, or whether we should not regard cultivation of orchards and inter-tilling of crops more in the nature of a necessary evil. A certain amount of tillage in the orchard is necessary to destroy summer growing weeds, to incorporate green manure and other organic manure into the soil, and often for the purpose of forming levees or drawing furrows for irrigation water, and in some cases to maintain the soil in such a physical condition that water penetrates readily. It is probable, however, that in all soil types, the less cultivation carried out when plants occupy the soil and the shallower this cultivation, so long as the essential

* None of these roots are shown in Fig. 2, as none happened to spring from the main root thereon.

objects are achieved, the better*. It has been found, for example, that inter-tillage of maize, at one time thought so essential, is definitely harmful unless carried out with great precaution†.

The very highly farmed citrus orchards of California were at one time kept very thoroughly cultivated. Later, the practice was questioned, and cultivation is now carried out as sparingly as possible, with apparently good results.

Deep cultivation is often considered necessary to promote soil aeration, and it is probable that aeration is a factor concerned in the development of the root zone; but as the upper limit of the root zone is determined by the depth of cultivation, and as diffusion is the chief agent of aeration, it is difficult to see how cultivation can beneficially effect the aeration of the root zone.

* It is realized, of course, that to achieve these essential objects rather frequent tillage seems inescapable: but our endeavours should perhaps be along such lines as to bring about these effects with as little interference with the roots as possible.

† Mosier, J. G., & Gustafson, A. F., 1915. "Soil Moisture and Tillage for Corn." Illin. Agr. Expt. Sta. Bull. 181.

A Moisture Equilibrium Survey for Timbers in the Capital Cities of Australia.

By C. Sibley Elliot, B.Sc. and A. J. Thomas, Dip.For.**

1. Introduction.

Insufficient drying or over-drying of the timber from which it is made must inevitably lead to trouble of a more or less serious nature when a wooden article—whether it be an expensive item of furniture, a door, a window, or any other similar object—is put into use. Knowledge of the range of moisture content variations of timber under normal conditions of use in any given district is therefore extremely important.

It was to obtain information of this nature that the present survey was commenced somewhat over two years ago (see this *Journal* 4 : 195, 1931). Observations were made throughout 1932 and 1933, and, from the mass of records collected, data of considerable importance have been compiled, and will shortly be published as one of the Council's publications. The present article gives a general description of the work and indicates the principal conclusions arrived at.

Work of a somewhat similar nature has been carried out in England by the Forest Products Research Laboratory, Princes Risborough (1); in the U.S.A. by the Forest Products Laboratory, Madison (2); in Canada by the Vancouver Laboratory of the Forest Products Laboratories of Canada (3); and in South Africa by the Research Branch,

* Officers of the Council's Division of Forest Products.

Forests Department, Pretoria (4). Tests limited to Sydney have also been carried out by Welch of the Sydney Technological Museum (5).

Acknowledgment is made of the help of the following co-operators, without whose assistance the survey could not have been carried out:— The Commonwealth Forestry Bureau, The Western Australian Forests Department, The Univerity of Adelaide, The University of Hobart, the Sydney Technological Museum, and the Queensland Forest Service.

Material for the tests was provided by the Forestry Departments of Western Australia, South Australia, Victoria, Tasmania, and Queensland, and by Messrs. Allen Taylor and Co. Ltd., of Sydney.

2. Scope of Survey.

It was not practicable, at the time, to include districts covering the complete range of climatic conditions occurring throughout the inhabited parts of the Commonwealth and, while information relevant to the capital cities meets the main requirements, it is desirable that the work should be extended, in the near future, to other important centres such as Kalgoorlie, Bendigo, and Broken Hill. Under the existing limitations, the capital cities were chosen as representative of the most closely populated districts of the Commonwealth.

In each of the seven capitals, samples of one of the most commonly used timbers grown in that district were held under observation. In Melbourne, in addition to the particular local timber, samples of the timbers allotted to each of the other centres were included for comparison. Douglas fir, as a common imported timber, was also included in the Melbourne observations. Further comparisons made in Melbourne were between dressed and undressed samples, between samples of various thicknesses, and between coated and uncoated samples. In the latter tests, four types of coatings were compared.

The timbers selected for observation in the several capital cities were as follows:—

Canberra.—*Eucalyptus gigantea*—Alpine ash.
Perth.—*Eucalyptus marginata*—Jarrah.
Adelaide.—*Pinus radiata* (*insignis*).—
Melbourne.—*Eucalyptus regnans*—Mountain ash (plus Douglas fir and all other selected species).
Hobart.—*Eucalyptus obliqua*—Brown top stringybark.
Sydney.—*Eucalyptus microcorys*—Tallow-wood.
Brisbane.—*Araucaria cunninghamii*—Hoop pine.

Each set of samples covered as nearly as possible the full range of density for the species, and each set consisted of three back-sawn and three quarter-sawn dressed and end-coated pieces, 18 inches long by approximately 6 inches wide by approximately ¾ inch thick (except in tests comparing the effect of thickness, in which ½ inch and 1½ inch thicknesses were included).

From each timber except mountain ash, four matched sets of samples were prepared. One set was placed in an outdoor sheltered position (protected from sun and rain) and one indoors, under ordinary office conditions, in the capital city to which the timber was allotted. The other two sets were placed in corresponding positions in Melbourne.

Mountain ash observations were confined to Melbourne. Comparisons of coated with uncoated samples and of samples of different thicknesses, were made indoors, in Melbourne, and comparisons of dressed and undressed samples were made out of doors, in Melbourne. For all these comparisons, hoop pine and mountain ash were used.

In Melbourne, weekly weights and measurements were obtained, and from these, variations in moisture content and size were recorded. In the other centres, similar observations were made monthly.

3. Summary of Findings.

In Fig. 1 is shown, to the nearest 1 per cent., the variation in moisture content to be expected with each of the timbers used, in both indoor and outdoor positions in each of the capital cities. So far as Melbourne is concerned, the graphs are plotted from actual observations in each instance. For each of the other centres, the graphs, apart from the one relating to the timber allotted to the particular centre, are plotted on the assumption that the comparative variation between species would be the same in all centres as in Melbourne. This assumption is not strictly correct, but is considered sufficiently accurate for practical purposes. Study of this figure shows several apparent discrepancies which are not due to the above assumption and which cannot be accounted for entirely by the fact that plottings are to the nearest 1 per cent. Further observations alone will enable these points to be cleared up.

In Fig. 2 are plotted two sets of moisture content variation curves showing that, whereas there is little difference between the month to month variation in moisture content of timber in Perth as compared with that in Melbourne, there is an appreciable difference between Sydney and Melbourne, especially in the summer months. These two cases have been chosen as examples, but comparison of minimum and maximum moisture contents in Melbourne and in each of the other capitals can be obtained from Fig. 1.

Two points of interest in Fig. 1 are the low equilibrium moisture content of Alpine ash as compared with the other species, and the large variation in moisture content of *Pinus radiata,* throughout the year, in sheltered outdoor positions. With regard to *Pinus radiata* figures, it should be noted that these were obtained from oven-drying determinations, which would probably give a moisture content about 1 per cent. higher than the actual, for this timber, on account of the volatiles present.

It was found that there was no appreciable difference in the moisture content variation of back-sawn and quarter-sawn boards. This is not in conformity with the results of tests at Princes Risborough, but the tests there were made on a timber with large rays, whereas all the timbers in these tests were small-rayed species.

It was found that neither thickness (within the limits of ½ inch to 1½ inches) nor smoothness of surface had appreciable effect on the limits of moisture content variation throughout the year, nor did the several coatings used have as much effect as was anticipated. The actual differences due to these factors will be shown in detail in the forthcoming publication referred to above.

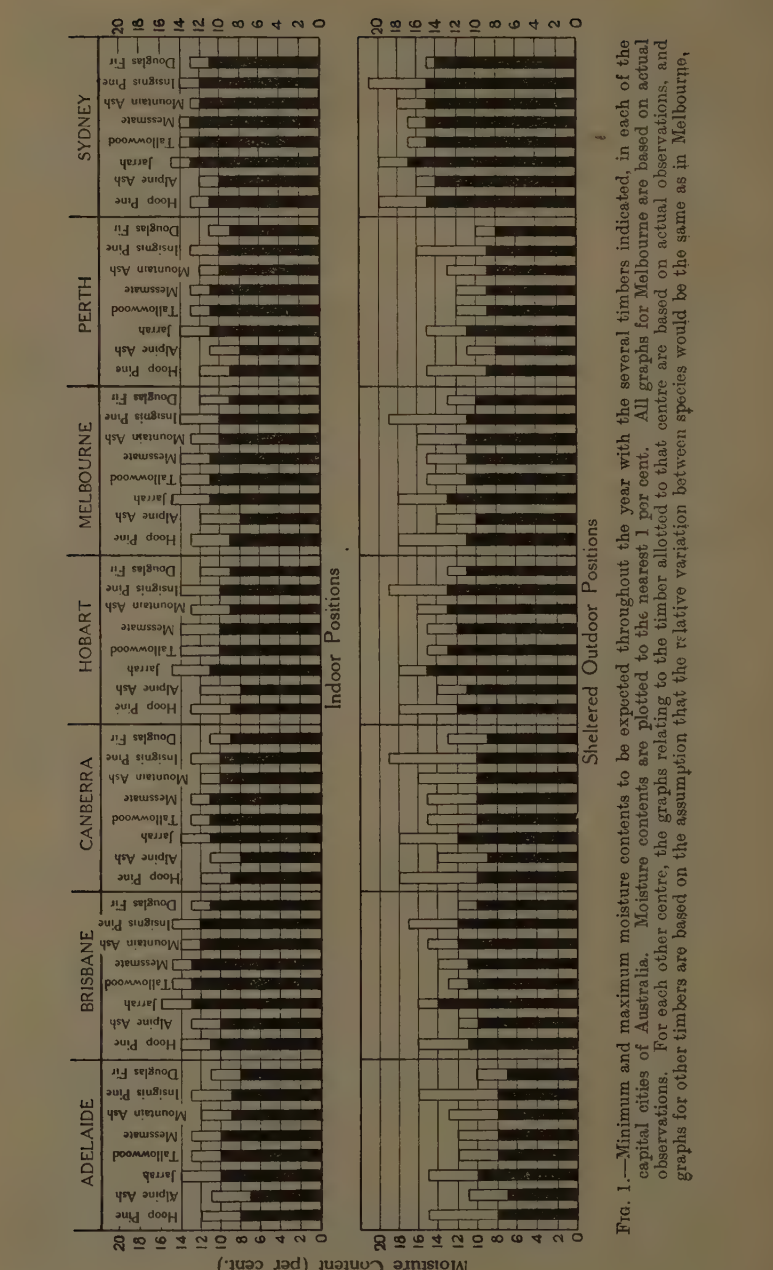

FIG. 1.—Minimum and maximum moisture contents to be expected throughout the year with the several timbers indicated, in each of the capital cities of Australia. Moisture contents are plotted to the nearest 1 per cent. All graphs for Melbourne are based on actual observations. For each other centre, the graphs relating to the timber allotted to that centre are based on actual observations, and graphs for other timbers are based on the assumption that the relative variation between species would be the same as in Melbourne.

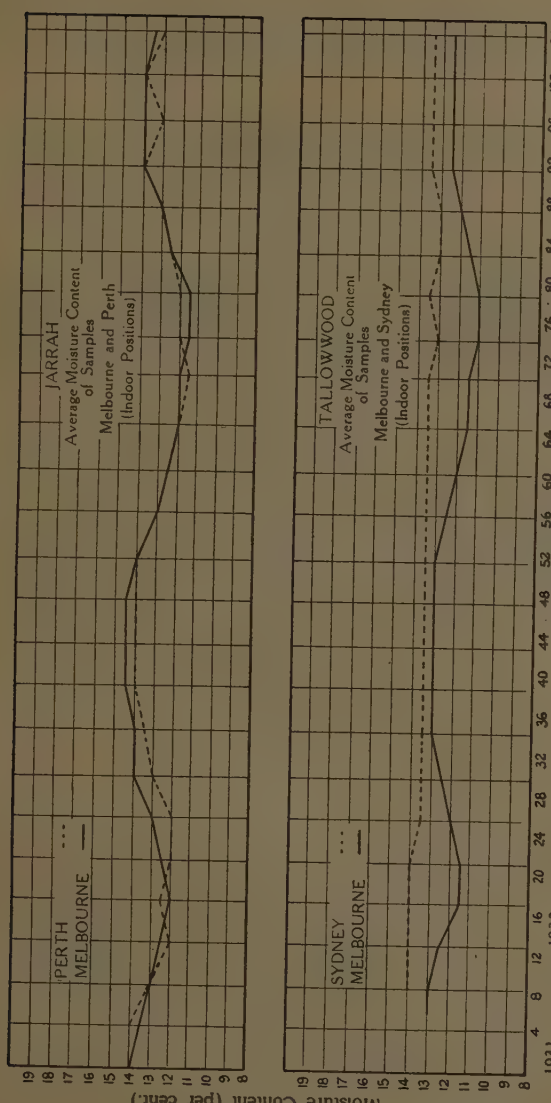

Fig. 2.—Comparison of equilibrium moisture content conditions of Melbourne and Perth and of Melbourne and Sydney (indoor positions).

The variation in size accompanying the yearly variation in moisture content is one of major importance from the practical point of view. This is illustrated in Fig. 3, in which the graphs are plotted from actual observations of variation in width of boards approximately 6 inches wide.

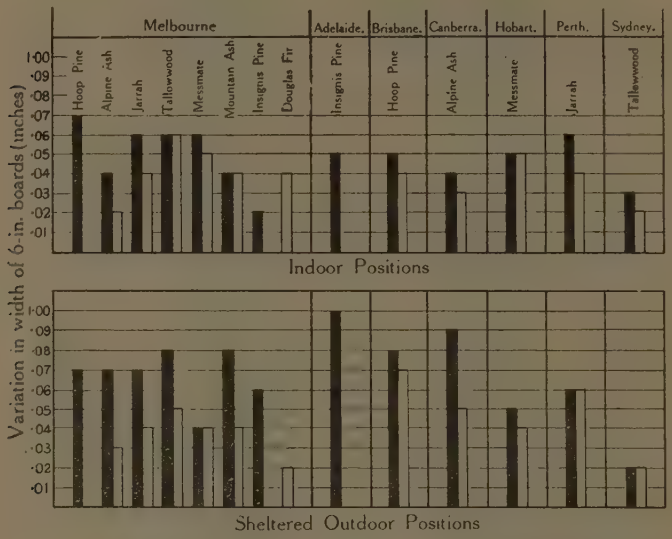

FIG. 3.—Average variation in width of boards approximately 6 inches wide, over same period as moisture content variations in Figs. 1 and 2.

Black column = back-sawn boards.

Blank column = quarter-sawn boards.

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Tests on Banana Cases.

By R. F. Turnbull, B.E. and I. Langlands, B.E.E.**

The investigations discussed in the following article were financed by a grant approved by the Commonwealth Banana Committee. This Committee was set up to advise the Commonwealth Government in regard to the distribution of funds amounting to not more than £5,000 per annum, and allocated by the Government to the assistance of the Australian banana growing industry.—Ed.

1. Introduction.

For a considerable time, the Section of Food Preservation of the C.S.I.R. has been investigating problems connected with the transport of bananas from Queensland and northern New South Wales to markets in the southern States. During these investigations, a certain amount of loss, due to mechanical failure of banana cases, was observed, and the Division of Forest Products was requested to study the problem with a view to reducing this loss.

A survey of the damage that actually occurs was undertaken by an officer of the Division, who made several visits to the railway station yards at Albury and at Spencer-street, Melbourne, to observe the condition of the cases at a trans-shipment point and on arrival at their destination. It was found, from detailed records of damage at Albury and observation of a large number of cases at Melbourne, that the visible losses were not sufficiently serious to require drastic alteration in the design of the case, yet were sufficient to justify investigations for improving the case.

In the general examination of delivered shipments, it was found that the most common failure of banana cases was due to nail heads pulling through the top boards. Other failures were caused by the wood shearing from the nails, withdrawal of nails, or breaking of top boards as the result of defects. Failure by the nails pulling through the top boards appeared to be caused by the use of excessively thin and soft timber, by excessive bulge, and by splits. It was apparent that several factors of construction and packing were varied in practice and that a study of these could be made more conveniently in the laboratory than by service tests. In service trials, many factors influence the condition of the case, e.g., the species of timber used, the care with which it is milled, the nailing, the extent of bulge, and the amount of rough handling. In a laboratory test, all factors except the one being studied can be kept constant, thus enabling the effect of each variable to be evaluated very much more quickly and cheaply than by service trials alone. The two types of investigation, however, are necessary for a complete solution of transport problems.

2. Description of Cases Used.

The type of banana case has been standardized, and is illustrated in Fig. 1. It is essentially a style 4 case† measuring internally 25″ x 12″ x 12″. Bulged packing is customary, the height of the bulge in the top varying from ¼″ up to 2½″, the latter in extreme cases.

* Officers of the Council's Division of Forest Products.

† C.S.I.R., Division of Forest Products, Trade Circular No. 10, "The Principles of Wooden Box Construction," page 6.

Usually, the ends are made of two pieces $\frac{3}{4}''$ thick, cleated together with two cleats $1\frac{3}{4}''$ wide x $\frac{3}{8}''$ thick approximately. The sides are generally in three pieces 5/16″ thick, although two-piece and four-piece sides are often observed. Tops and bottoms are mostly two-piece, 5/16″ thick.

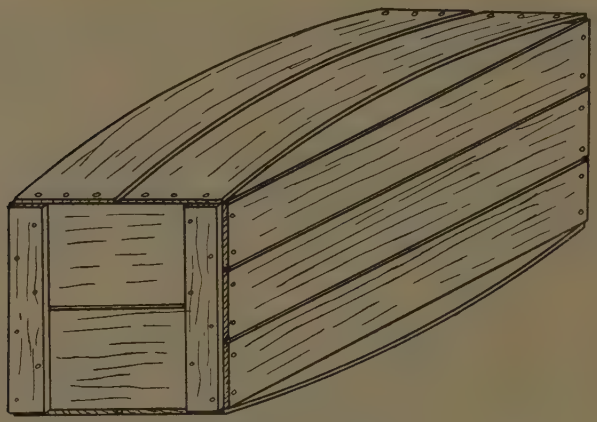

Fig. 1.—Standard Banana Case.

In making up the cases, the sides are usually placed parallel to the cleat, although it is not uncommon to find the tops and bottoms in this position. The latter practice is undesirable, because the nails holding the top and bottom are then driven into the end grain of the end pieces. The end grain has much less nail holding power than the side grain, and, consequently, with this method of construction, withdrawal of the nails holding the tops is common.

Timber is supplied green from the saw, and hoop pine (*Araucaria cunninghamii*) and rose gum (*Eucalyptus saligna* and *Eucalyptus grandis*) are the timbers most frequently used. A miscellaneous array of brush timbers, both softwood and hardwood, are also used. It has been stated that the tops and bottoms of hoop pine shooks are generally milled 1/16″ thicker than those of other species.

In practice, there is considerable variation in the shooks, the most noticeable being in the thickness of top and bottom boards, actual thicknesses ranging from $\frac{1}{8}''$ to $\frac{3}{8}''$.

The nails most favoured are $1\frac{3}{4}''$ long by 14 gauge with 6 nails driven per edge.

3. Procedure in Laboratory Tests.

The tests in this study were confined to an investigation of the influence of the various construction details on the strength of banana cases. Other studies concerning the effect of different methods of packing on the bruising of the fruit are being conducted by the Section of Food Preservation.

The principal factors affecting the strength of the case in service are as follows:—

(i) Species of timber.
(ii) Thickness of timber.
(iii) Nailing schedule.
(iv) Wiring.
(v) Extent of bulge.

The laboratory tests were designed to determine the influence of these factors when varied within commercial limits.

Consignments of case shooks of five species were obtained through the agency of the Queensland Forest Service. Cases were made up in the green condition, using two variations of thickness of top and bottom boards, two nailing schedules, packed with three heights of bulge, wired and not wired. With three species, all possible combinations of the remaining four variables were constructed, and with the other two species, factors (ii) and (iv) were varied and two heights of bulge were used. Sixty different combinations of factors were tested and repeated in triplicate, this involving the testing of 180 cases.

The variations were as follows:—

1. *Species of Timber.*

The species subjected to major tests were—

(i) Rose gum representing comparatively hard, dense, and strong timbers.
(ii) Hoop pine, representing softwoods, i.e., conifers.
(iii) Blush cudgerie (*Euroschinus falcatus*) representing relatively weak and soft brush timbers. With this species, hoop pine case ends were used as the result of advice from the Queensland Forest Service.

At the request of the Queensland Forest Service, comparative tests were carried out with blackbutt (*Eucalyptus pilularis*) and white gum (*Eucalyptus micrantha*). These are secondary hardwood timbers for which market extensions are being sought.

2. *Thickness of Timber.*

The cases were all made with sides of a standard thickness of 5/16″, but the following variations were tested in the thickness of the tops and bottoms:—

Hoop pine .. Tops and bottoms 5/16″ and $\frac{3}{8}$″.
Other species .. Tops and bottoms $\frac{1}{4}$″ and 5/16″.

3. *Nailing Schedule.*

The nailing schedules used were:—

(*a*) 6 nails, $1\frac{3}{4}$″ x 14 gauge, in tops, bottoms and sides;
(*b*) 6 nails, $1\frac{3}{4}$″ x 14 gauge in sides; and
8 nails, $1\frac{3}{4}$″ x 14 gauge in tops and bottoms.

Schedule (*a*) was used with five species, but (*b*) was used only with rose gum, hoop pine, and blush cudgerie.

4. *Wiring.*

The effect of wiring was studied by packing cases in pairs and testing one wired and one unwired. The tests were confined to the lesser thicknesses in each species. The wires used were Gerrard O.D.S. type, and were placed transversely round the cases at about 1½″ from the ends.

5. *The Extent of Bulge.*

The cases were packed with bananas according to the recommendations of the Queensland Department of Agriculture. Green "sixes" were used throughout, and the packing was done by a commercial packer. The only variations introduced in the packing were those necessary to obtain various bulges. Bulges of ½″, and 1½″ and 2″, measured in the top boards, were used in the tests according to the following scheme:—

Species.	Thickness Top and Bottom.	Bulges Used.
Hoop pine	$\frac{5}{16}$″	½″, 1½″, and 2″
	⅜″	½″ and 1½″
Rose gum	¼″	½″, 1½″, and 2″
Blush cudgerie	$\frac{5}{16}$″	½″ and 1½″
Blackbutt	¼″	½″ and 1½″
White gum	$\frac{5}{16}$″	

It was found that, with the thicker and stiffer boards, large bulges were difficult to obtain. Blush cudgerie appeared to be most easily bent and hoop pine relatively so.

Tests.—Cases were tested to destruction in the case-testing machine*. Every nailing edge of the case was numbered in the standard manner, and the development of failures observed and recorded. The number of drops necessary to spill the contents of the case was taken as the basis for determining the influence of the variable factors.

4. Results.

Species.—On the basis of all variables considered, the eucalypt timbers, i.e., rose gum, white gum, and blackbutt, made the strongest cases. It was apparent, however, that, although timbers of the blush cudgerie type ranked among the weakest, careful attention to detail will produce serviceable cases. The outstanding feature was the performance of white gum and blackbutt.

It was noticeable that in the test consignments the milling of white gum and blackbutt was far superior to that of the other hardwoods. The quality of the blackbutt was very high, a large proportion being free from defects and well sawn. The white gum, although well sawn, contained a noticeable quantity of fine gum veins. The rose gum was badly sawn, the variations in thickness and the uneven sawing defect

* *J. Coun. Sci. Ind. Res.*, **5**: 68, 1932.

known as "weatherboarding," being unnecessarily prevalent. The "weatherboarding" is shown in Fig. 2, which is a photograph of some of the shooks received. The rose gum shooks also varied in width and length, and contained a relatively high proportion of defective material. Controlled tests with this timber would have been impossible if machinery had not been available for sawing and machining shooks to a definite specification. In some cases of the eucalypt timbers, the presence of brittle "heart" in the top boards accounted for abrupt failures after very little rough handling and made evident the necessity for eliminating "heart" in case timber.

FIG. 2.—Illustration of actual shooks of rose gum sawn by the trade for case manufacture. The photograph is not in perspective, and shows the wide variation in thickness from edge to edge.

Thickness of Timber.—The tests showed, as was expected, that reducing the thickness of the top and bottom boards decreased strength. With hardwoods, a change from 5/16″ to ¼″ thickness in top and bottom caused an average decrease of 40 per cent. in strength, while with hoop pine the change from ⅜″ to 5/16″ produced a 16 per cent. average decrease in strength.

Nailing Schedule.—The increase in number of nails in the tops and bottoms from 6 to 8 greatly reduced the proportion of failures in these positions, particularly with the lesser thicknesses and the softer species, and resulted in an average increase in strength of 38 per cent.

Wiring.—The use of wires proved the most significant factor in increasing the strength of cases, the wired cases being on the average four times as strong as the corresponding unwired cases.

Bulges.—The comparison in strength with cases packed with various bulges tended to show that the strength decreased as the bulge increased. It appeared, however, that up to a limit of 1½″ bulge in the top boards, the reduction in strength was not serious, but beyond this limit dangerous weaknesses were introduced.

5. Conclusions.

The serviceability of banana cases appears to depend upon the following factors, in order of importance:—

(i) The use of wire strappings.

(ii) The thickness of top and bottom boards.

(iii) The pack (i.e., the height of bulge, if above 1½″).

(iv) The nailing schedule.

(v) The species of timber used in case construction.

If rigid supervision were exercised in eliminating thin boards from the tops and bottoms, the bulge would be automatically limited to approximately 1½″. In practice, it has been observed that failures of cases are generally associated with high bulges. To get these high bulges it has been necessary to use thin tops. These two factors in combination lead to early failure.

Information concerning the costs involved in standardizing upon one definite method of construction is not available. The tests established the variations in strength that can be expected when certain features of construction are altered, and it should be possible, if complaints of breakages are being received, to effect an improvement by adjusting one or more of the above features.

With the eucalypts, the ¼″ tops and bottoms produced cases as strong as 5/16″ thickness in other timbers. Hence there is apparently no need to exceed the ¼″ thickness with the eucalypts, but it is important that this should be the minimum finished size. It is advisable to keep the 5/16″ thickness in the case sides to preserve general rigidity. With hoop pine and blush cudgerie, ¼″ tops and bottoms would be too thin unless 8 nails were used in them and the cases were wired.

The relative prices of cases made from various timbers in different banana packing districts varies, and consequently one species cannot reasonably be recommended for general adoption. The tests show that, if certain features in construction are modified, a much greater variation in strength can result within a species, than between species. From the standpoint of strength, the secondary timbers, blackbutt and white gum, are capable of providing cases at least equal to those of timbers at present in use, provided that the milling is up to the standard of that of the material submitted for test. If the uneven sawing and amount of defect found in the rose gum is permitted in other species, it will be impossible to ensure the construction of reliable cases. The most important step towards obtaining stronger cases is to mill carefully and strictly adhere to a definite specification. By eliminating thin or defective shooks, the present losses in banana transport could be materially reduced.

Butter Taint—The Viscosity of Casein-Borax Solutions.

*By W. J. Wiley, D.Sc.**

The work discussed in the brief note that follows was carried out by Dr. Wiley after he had left the service of the Council and had joined the staff of the Queensland Government Chemical Laboratory. It is published below by kind permission of Mr. J. B. Henderson, Queensland Government Analyst.—Ed.

The treatment of butter boxes which was developed by the Council for Scientific and Industrial Research to prevent wood-tainting of the butter (this *Journal,* **5** : 1, 1932) necessitates the spraying of a casein solution with a spray gun. It is desirable to have the solution as concentrated as possible in order that the minimum quantity of water, which must be evaporated for drying, be applied. The casein concentration, however, is limited by the fact that only solutions up to a certain viscosity can be successfully sprayed.

For a given viscosity, the concentration of casein in a solution is determined by the nature of the casein used, the nature and concentration of the alkaline solvent, and the temperature. The casein which has been found best suited for the butter box treatment is Australian "Prime Lactic," a self sour casein which is of comparatively uniform grade. Solvents which give a more alkaline and less viscous solution than borax are unsuitable, as they cause a decided deepening in the colour of the wood to which they are applied. It was therefore decided to investigate the variations in viscosity of casein in borax solutions of various concentrations and at various temperatures, as by working at elevated temperatures it might be possible to use considerably more concentrated solutions than are possible at normal temperatures.

Casein solutions were prepared of the following compositions:—

	Solution.		
	No. 1.	No. 2.	No. 3.
	Grams.	Grams.	Grams.
Casein (Prime Lactic)	50	50	50
Borax	7·5	7·5	7·5
Water	300	225	150

Several samples of Australian "Prime Lactic" casein were tested. The variations in viscosity obtained with the different caseins was less than 10 per cent., and as, for the present purpose, this was unimportant, the mean results are shown diagrammatically in Fig. 1.

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The comparative viscosities were determined in a viscometer of the co-axial bulb type. The figures recorded as viscosity are the time in seconds required for a fixed volume of solution to flow through the orifice. As comparative results only were required, no attempt was made to convert the figures to absolute units, and, in any case, it is doubtful if at the lower temperatures the flow was truly viscous.

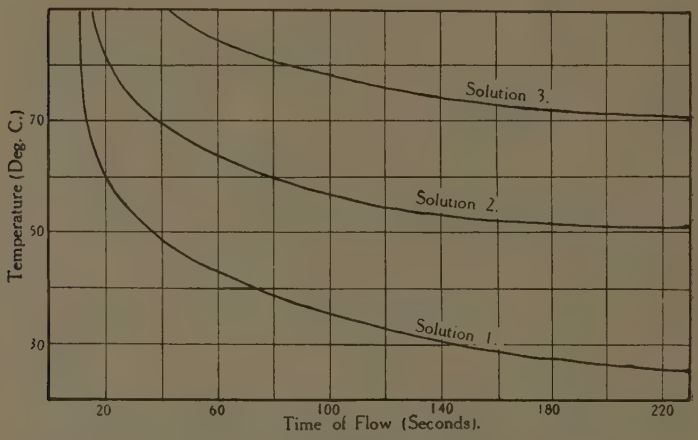

FIG. 1.—Curves illustrating the different viscosities of different casein solutions.

Solution 1 is of the same concentration as has been used in practice and found to spray satisfactorily at a temperature of about 25° C. (77° F.), so that a viscosity of 220 on the arbitrary scale can be taken as suitable. The results show that a solution containing half as much water would have to be at a temperature of about 70° C. (158° F.) to be handled by the spray gun. Such a hot concentrated solution was tested by spraying, but although the desired quantity of solution was delivered, results were unsatisfactory, as the spray cooled so quickly that the droplets on hitting the wood were too viscous to flow together into a uniform coat before gelling due to the reaction with formalin which is sprayed from another gun at the same time. Solution 2 suffered from the same defect but to a minor extent, and such a solution warmed to 50° C. (122° F.) would appear to be of about the maximum concentration applicable by present methods. As the proportion of water in it is 75 per cent. of that in solution 1, it is problematical if the saving in drying would recompense for the additional equipment necessary for keeping it warm.

The author is very grateful to Mr. J. B. Henderson, Queensland Government Analyst, for permission to do this work in his laboratories.

Notes on a Soil Map of Tasmania.

*By C. G. Stephens, M.Sc.**

The accompanying map† illustrating the distribution of the principal soil zones of Tasmania has been prepared as a result of the interpretation of relevant data collected during a period of about three years. Much of the information essential for the compilation of the map was collected with the assistance of officers of the Forestry Department and of the Department of Agriculture; to these the author is indebted. The geological map issued by the Mines Department and the climatological and contour maps issued by the Commonwealth Meteorological Bureau were used to assist in the plotting of the soil boundaries.

The method employed was to determine for any particular district of consistent climate and elevation the soil types associated with the different geological features. After checking, where possible by personal observation or by soil samples sent in by the State Departments, the different soil zones were then mapped. In many cases, the information available could not be shown on the map owing to the small scale used. This applies particularly to some portions of the West Coast and to the mapping of the black soils in southern Tasmania as well as to alluvial soils.

Apart from the alluvial soils, of which there are several important series in Tasmania, six major soil zones have been recognized.

1. Grey podsolised sands, sandy loams, or less frequently loams usually with a fairly large accumulation of organic matter in the surface horizon, overlying a subsoil of yellow and grey clay. Frequently grey, black, or brown hardpans overly the subsoil. The pH values of surface soils and hardpans are at about 4.5 and of subsoils from 4.5 to 5.0.

Native vegetation: Rain and sclerophyll forests and heath.

Economic uses: Orchards and, of later years, pastures; a small amount of mixed farming. The source of the great majority of the timber of the State.

2. Brown earths: loams with some organic matter over brown clays with calcium carbonate. Frequently shallow and very stony. pH values of surface soils from 6.5 to 7, and of subsoils from 7 to 8.

Native vegetation: Savannah woodlands: eucalypts, acacias, and *Danthonia*.

Economic uses: Very largely sheep grazing with some mixed farming.

3. Black soils. Black clay loam of some depth over yellow clay with calcium carbonate. pH values of surface soils at about 6.5 and of subsoil from 7 to 7.5.

Native vegetation: Sclerophyll woodlands.

Economic uses: Mixed farming and cereals.

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* An officer of the Council's Division of Soils accommodated at the University of Tasmania.

† On page 103.

1. Podsolised soils. Chiefly sands or sandy loams over yellow and grey clays.
2. Brown earths. Loam over brown clays with calcium carbonate.
3. Black soils. Black clay loam over yellow clay with calcium carbonate.
4. Red soils Deep, red, self-mulching, heavy soils of indistinct profile.

4a. Red soils with distinct profile development.

4b. Red soils—shallow phases.

5. Button grass plains. Peat or sandy peat over grey sand. Extremely acid soils.
6. High moor soils. Peat over yellow and grey clays, frequently denuded.

7. Mixture of types (see text).

4. Red or chocolate soils. A red, self-mulching, heavy soil of considerable depth with no obvious profile beyond the accumulation of organic matter in the surface soil and sometimes concretions (iron or manganese oxides) in the subsoil.

4A. Profile distinct with a definite red brown clay subsoil; confined to elevated country.

4B. Shallow and stony phase of 4.

pH values of surface soils from 5 to 6.5 and of subsoils from 4.75 to 6.

Native vegetation: Wet sclerophyll forests.

Economic uses: Potato growing and mixed farming.

5. Button grass plain soils. Two phases.

Elevated phase: Grey organic sand over grey sand often with hardpans. Rounded quartzite stones always present in the profile. pH values of surface soils from 4.0 to 4.5, and of subsoils at about 4.5.

Native vegetation: The Cyperaceous button grass (*Mesomelaena sphaerocephala*) and heath.

Low lying phase: A black peat overlying a grey sand with a varying content of organic matter. pH values of surface soils at about 3.5 and of subsoils at about 4.0.

Native vegetation: Button grass (*Mesomelaena sphaerocephala*).

Economic uses: Practically nil beyond a small amount of rough grazing.

6. High moor soils. Dark grey peat over yellow clay very frequently denuded. pH values of surface soils at about 4.5 and of subsoils at about 5.0.

Native vegetation: Tussock grass (*Poa* sp.) and heath.

Economic uses: Summer grazing of sheep.

A Preliminary Note on the Recognition of Flag Smut or Bunt Infection Based on the Deformation of Seedlings.

*By H. R. Angell, B.Sc.Agr., M.S., Ph.D.**

1. Introduction.

As far as the writer is aware, no constant and easily recognized signs of bunt or flag smut infection have been hitherto recorded, except the well-known smutted heads of the former or the sori of the latter. Previous results of infection experiments have indicated that environmental conditions during the growth of the plants influence the progress of the organisms in the host, preventing, in some cases, maturation of the fungi concerned. Therefore, some of the presumably infected plants have failed to show the familiar symptoms. Consequently, it has been impracticable to distinguish between individuals that have escaped infection and those that have resisted the disease.

On the other hand, under the controlled environmental conditions here reported, deformation of infected seedlings, sufficiently pronounced to distinguish the majority of such seedlings from the uninfected, is readily obtained. Infected seedlings can, with few exceptions, be distinguished from healthy ones when the majority of the coleoptiles are ruptured. Studies on resistance and susceptibility should therefore be facilitated by the use of the methods described in the following account.

2. Flag Smut Experiments.

According to the work of Griffiths (3), Noble (4), and Verwoerd (5), the optimal temperature for infection with *Urocystis tritici* is in the neighbourhood of 20°C. This temperature is maintained, with but slight variation during the greater part of the year, in a portion of the unlighted basement of the laboratories of the Division of the Plant Industry in Canberra. It was therefore used for the work reported here.

A sandy loam, partially sterilized by steam at atmospheric pressure for four hours, was air-dried, mixed with water to the extent of 40 per cent. of its moisture-holding capacity, and transferred in 6-inch pots to the basement. Spores of the organism were desiccated over fused calcium chloride for 3 weeks, and subsequently stored in a desiccator in the laboratory until required. For three days prior to their being used as inoculum, the spores were soaked in soil solution at 20°C. Kernels of Canberra wheat, a variety very susceptible to flag-smut, were shaken with the concentrated spore suspension, and planted at depths varying by ½ inch intervals from ½ inch to 2½ inches. One hundred kernels were placed at each of the respective depths. Similarly, 10 pots, each planted with 10 kernels, covered with a concentrated suspension of dead spores in soil solution, served as controls for each depth of planting.

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When the majority of the coleoptiles were ruptured by the first true leaf, the pots were removed from the basement to benches out of doors. From the time the coleoptiles began to appear above the ground, there was an obvious difference between those in the inoculated series sown at ½ inch and 1 inch, and their respective controls. The latter were nearly all straight and erect; the majority of the former were twisted, curled, and inclined, as is clearly shown in Plate 1, Fig. 1. On the contrary, no difference could be observed between the inoculated and control series planted at 2 inches and 2½ inches. The inoculated series were, however, equally heavily infected, as was evident some weeks later by the appearance of the well-known leaf symptoms. Shallow planting, therefore, was an important factor in the production of the early symptoms. The results of shallow and deep planting, respectively, are shown in Plate 1, Fig. 2, which is reproduced from a photograph taken of another experiment. In Plate 1, Fig. 3, the control seedlings from one of these pots are shown in the upper row and the inoculated ones sown at ½-inch deep in the lower row.

Similar tests, with the same results, have since been made with a few other resistant and susceptible varieties. Among the latter, characteristic twisting and inclination has been observed in the majority of the seedlings, whereas, in some resistant varieties, only a low percentage has differed from the controls. It is desirable, however, to test other varieties before the advantages and limitations of these early symptoms, as indicative of relative resistance, can be determined.

The deformation is not in every case equally definite. In every inoculated series, a few seedlings among the susceptible, and many in the more resistant varieties, are so slightly twisted or bent as to make it difficult to differentiate from the slight bending which may occur in a few of the controls. Although these doubtful cases occur, the method shows distinct promise of being a reasonably accurate means of determining the amount of infection and of classifying varieties according to their resistance to infection. In addition, it will now be practicable, by comparison of the numbers of deformed seedlings and the resulting mature plants showing the usual symptoms, to determine the percentage of infected plants that resisted further development of the disease. Hitherto, it has been difficult, if not impossible, to distinguish between such plants and those that escaped infection.

Since Geach (2) has shown that, even in reputedly resistant varieties, seedling blight results from the joint attack of *Fusarium culmorum* and *U. tritici*, and in the writer's experiments as much as 40 per cent. of seedlings infected with flag smut have been killed by species of *Fusarium* naturally occurring in the soil, it is imperative that, if infected seedlings are to be grown to maturity without undue loss by seedling blight, sterilized soil should be used for germination.

3. Bunt Experiments.

The bunt experiments were made in an incubator at 10°C. According to Faris (1), a high percentage of bunted plants is obtained at this temperature. The type of soil already mentioned was used, its moisture being adjusted to 60 per cent. of its holding capacity. Two varieties of wheat, Florence and Federation, were tested with the results illustrated in Plate 2, Fig. 1. Those shown in Plate 2, Fig. 2 were sown

in unsterilized soil. After germination, they were kept in the dark for four days at an average temperature of 4°C. before being photographed. Most of the seedlings in the inoculated sets were twisted and bent. Those of Florence, a reputedly resistant variety, were more deformed than those of Federation.

In passing, it may be remarked that attack by *Fusarium* spp. was much more apparent among the infected seedlings than among the controls.

4. Conclusions and Summary.

From these results, it is evident that under the conditions described, infection with flag smut or bunt is demonstrated by deformation of very young seedlings. The total amount of infection may be more accurately determined on this basis than was previously possible, because the incidence of seedling blight, the failure of the usual symptoms to develop in all the plants originally infected, and the hitherto undeterminable factor of escape from infection all interfered with the results. Furthermore, it is now possible to differentiate between resistance to infection and resistance to the development of the disease. The relative resistance of varieties to infection may be determined easily and quickly. On account of the saving of time and effort, the method appears to have some advantage over greenhouse and field tests of resistance, particularly as the environment can be standardized.

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PLATE 1.

Fig. 1 (top). *The Effect of Flag Smut Infection on Canberra Wheat.*—On the left of the photograph are ten pots of control seedlings. Most of them are erect, but some have fallen over on account of mechanical injury. Those in the ten pots on the right are twisted and inclined, the result of flag smut infection. Since the photograph was made, 75 per cent. of the latter have shown the usual symptoms of the disease.

Fig. 2 (centre). *Illustrating the Effect of Depth of Planting.*—In the foreground are five pots sown at ½ inch deep. The control pot is on the left, the others are inoculated with flag smut spores. The pots in the background were sown at 2 inches deep. There is no obvious difference between inoculated and the un-inoculated seedlings sown at the latter depth.

Fig. 3 (bottom). *Healthy and Infected Seedlings.*—The seedlings in the upper row are controls sown at ½ inch deep; those in the lower row were inoculated with flag smut spores. Note that all in the lower row are bent except five at the right of the photograph.

FIG. 1 (top). *The Effect of Bunt on Florence and Federation Wheat.*—Control seedlings of Florence wheat are shown in the upper left, and of Federation in the lower left of the photograph. To the right of the respective controls are shown inoculated seedlings of the same varieties. Twisting of some of the latter is clearly illustrated.

FIG. 2 (bottom). *The Effect of Bunt on Florence Wheat.*—These seedlings were grown in unsterilized soil. Those on the left were not inoculated with bunt; those on the right were. After removal from the incubator, they were kept for four days in darkness at an average temperature of 4° C. The bunt infected seedlings are deformed, the injury being increased by attack by species of *Fusarium*.

NOTES.

Recent Alterations and Additions to the Brisbane Food Preservation Research Laboratory.

In a previous issue (**5**: 255, 1932), an account was given of the nature of the buildings and equipment provided by the Queensland Meat Industry Board for the Council's investigations on meat preservation.

In view of the urgency of the problem of the export of chilled beef from Australia, the need for an acceleration of the experimental work in this connexion became apparent toward the end of last year. The more intensive attack which had been planned required, in turn, the provision of further refrigerated space. To meet this need, the Board of the Commonwealth Bank of Australia generously donated from its Rural Credits Development Fund the sum of £900 to enable the Queensland Meat Industry Board to erect the necessary alterations and additions. The constructional work was completed in November last, and the extra refrigerated space was immediately put into operation.

The original experimental cold storage accommodation was situated on one side of an insulated air lock; a new brine tank room and small cold store have now been built on the opposite side, the whole forming a compact block. The new brine tank room is equipped with two tanks for the supply of refrigerating brine at two temperatures, cooling being carried out by means of coils of direct ammonia expansion pipes connected to the Abattoir mains. The pumps for each of the four rooms cooled by the brine have been equipped with interconnecting pipes and valves to enable each to obtain brine from either tank as required. The additional cold room, having approximately 90 square feet of floor space, is being fitted as a low temperature laboratory where such operations as the examination of pieces of meat and microbial growths and the sub-culture of "low temperature type" micro-organisms may be carried out under ideal conditions. Three constant-temperature cabinets are shortly being installed in this room, and, in these, the rates of growth of micro-organisms capable of comparatively rapid growth on chilled beef will be studied at different temperatures and in several concentrations of carbon dioxide.

Alterations have been effected in two rooms of the original cold storage block. The equipment in the old brine tank room has been transferred to the new room, and the old room has been more heavily insulated, and wall and ceiling grids of brine pipes have been erected. This room is now being employed as an incubator kept at a temperature of $-1°C.$ (30.2°F.) for the study of "low temperature type" micro-organisms obtained from beef and from various sources in many meatworks. To enable a simultaneous comparison to be made of the effects of different concentrations of carbon dioxide on the storage "life" of chilled beef, an additional beef storage chamber has been made gas tight by the provision of an internal lining of galvanized sheet iron and of a new, tightly-fitting, insulated door.

The Parliamentary Science Committee (Great Britain).

Advice has recently been received in Australia in regard to the formation in Great Britain of a body known as the Parliamentary Science Committee.

The object of the new body is briefly to provide a non-party organization "to serve as a link between Science and Parliament," and to enable full use to be made of scientific information in the counsels of the Empire. Among the means by which the Committee hopes to achieve its objects are the preparation of authoritative memoranda on scientific matters in relation to economic policy and national well-being, addresses by eminent men of science, questions in Parliament on scientific aspects, and the examination of Bills which involve scientific considerations.

The Committee also proposes to press for the improvement of the financing of scientific research work, pointing out the desirability of the endowment of research outright, or alternatively, for the making of block grants for a period of at least five years, and stressing the expense and lack of economy of fluctuating annual allotments alternating with retrenchment; further, to press for all scientific and technical departments in the Public Service, and of work involving scientific knowledge, being under the direct control of persons of adequate scientific attainments, and for no scientific or technical worker employed by the State and possessing the necessary administrative ability to be debarred in any way from rising to the highest appointments in the Public Service.

To help in maintaining touch with its members the Committee has arranged to issue a summary of all scientific matters dealt with in Parliament. The title of this periodical is "Science in Parliament." In addition, the Committee is taking steps to form a small reference library dealing with science in public affairs. Gifts towards its formation, including copies of important State papers and other documents, would be welcomed.

The Mineral Content of Pastures—Grant by Carnegie Trust.

For some years past, investigations have been in progress on the mineral content of pastures under a co-operative scheme between the Empire Marketing Board, the Waite Agricultural Research Institute, and C.S.I.R. The early history of the work and the precise lines of the co-operation were described in detail in the Council's Pamphlet No. 17. Briefly, each of the co-operating parties provided one-third of the cost of the necessary laboratory building. In addition, the bodies concerned met the maintenance cost on the basis of the Empire Marketing Board, contributing an amount of up to £1,875 per annum, and the Institute and the Council a similar amount between them.

In view of the termination of the Empire Marketing grant, an offer was made by the Carnegie Trust to contribute a sum of £1,750 for one year and a sum of £900 for a second year towards the cost of the investigations. The offer was made conditional on the continuation of the work after the close of the second year. The University of Adelaide has undertaken that the work will be maintained after the expiry of the Carnegie grants, and the offer has accordingly been accepted with gratitude.

Future of Empire Marketing Board Grants to Australian Research Work.

Some recent decisions which affect Australia and which followed the abolition of the Empire Marketing Board as from the 1st October, 1933, are as follows:—

In addition to providing considerable funds for various investigations of more local concern, the British Government has undertaken to accept the full responsibility—£15,000 per annum—for continuing the Board's former grants to the East Malling Horticultural Station, the Aberystwyth Plant Breeding Station, the Long Ashton Horticultural Station, the Kew Economic Botanist, and the Investigation of Milk Examination Technique, and at the same time to maintain full Imperial significance to the work included under these five headings.

The Commonwealth Government, for its part, has agreed to continue the Board's Australian grants as from the 1st July, 1934; in other words, to provide £4,000-£5,000 per annum as half the cost of the co-operative cattle research work being carried out at Townsville, and £2,000-£3,000 per annum as half the cost of the sheep research work being carried out under the Australian Pastoral Research Trust—E.M.B. scheme.

Another decision of the Commonwealth Government is to contribute £5,800 per annum as a portion of the Board's former grants to the Low Temperature Research Station, Cambridge, to the entomological work at Farnham Royal, and to the work on insect infestation on stored prdoucts at Slough. The investigations at these places are all of considerable moment to Australian primary producers.

The other Dominions are also considering continuing the Board's former grants to work in their respective domains; the South African Government has already undertaken to meet the cost of the unexpired portion of the Board's former grant of £10,000 per annum to the veterinary work at Onderstepoort.

Sheep Blowfly Investigations at "Cranmore Park," W.A.

By the kind co-operation of the Boolardy Pastoral Company Ltd., owners, and Mr. E. H. B. Lefroy, resident manager, Miss M. Fuller, of the Division of Economic Entomology, carried out investigations into trapping and certain other aspects of the blowfly problem at "Cranmore Park," near Walebing, Western Australia, from August to November of last year.

The main purpose of the investigation was to study the effect of trapping on the incidence of strike in sheep. Two paddocks were used for this experiment, each stocked with similar sheep and equally grazed, one being trapped and the other kept as a control. A record was kept of every sheep struck in both paddocks. This experiment will be continued next season.

In conjunction with the trapping experiment, field tests were made of the treatment of baits by sodium sulphide, certain of the traps being baited with sulphide-treated baits, while others, baited with untreated carrion, were used as controls. Traps in which sulphide-treated baits were used caught three times as many flies as untreated traps.

Miss Fuller found that *Lucilia cuprina* was abundant in the inland sheep districts visited, where it is just as important a primary sheep fly as it is in the eastern States. Early in the season, however, many of the strikes in sheep at "Cranmore Park" were caused by *Calliphora nociva,* a species which is very closely related to the eastern *C. augur.*

Division of Forest Products—Extension of Laboratory Buildings.

Recently, it became necessary to erect further buildings to house the rapidly extending work in the Division of Forest Products, and permission was obtained to use, for this purpose, portion of the garden on the site at 314 Albert-street, East Melbourne, where the Division already occupies a collection of temporary buildings. The new buildings have been erected by the Division's staff, assisted by the necessary labour; they embody a number of special features which are of interest. The opportunity has been taken to make the buildings serve, not only for accommodation, but as a method of furnishing experimental evidence on a practical scale in a number of problems in which the Division is interested.

There are two main parts in the additions, one built a year ago, covering an area of 60 feet x 45 feet, and the more recent, erected in March of this year, which is 52 feet x 45 feet. These house the timber mechanics' laboratory, draughting room, dark room, woodworking shop, offices, and stores.

In the construction, Australian hardwood has been used throughout. The weatherboards, linings, and floorings are all kiln dried and reconditioned. Doors and window sashes are also of kiln dried hardwood. Lining and weatherboards are of merchantable grade, and the flooring consists of rejects from this grade. An inspection of the buildings will show that even such rejects make a very good floor. Dimensions of structural members have been reduced below those usually specified, e.g., the studs are 3 inches x 1½ inches instead of the usual 4 inches x 2 inches. By taking advantage of the natural strength and stiffness of hardwood, many standard dimensions can be reduced, and in this way drying is simpler, and one of the disadvantages of hardwood, viz., its weight, can be considerably modified. Where three-ply lining has been used, the edges of the ply have been treated in various ways to prevent ingress of the powder post borer (*Lyctus brunneus*).

In the roof scantling, a fair amount of sapwood has been allowed. This sapwood has been treated with a number of different preservative fluids. As sapwood is very liable to attack by *Lyctus,* and as just below is the wood store in which there will be many hundreds of samples badly infested with this borer, there will be a good opportunity for testing the relative value of the preservative methods adopted.

At various portions of the foundations, flooring studs, and roof structure, there are fixed permanent insulated wire leads attached to copper nails driven into the timbers and brought out to easily accessible positions. These can be readily linked to a "blinker" moisture-meter, and regular readings of the moisture content of these various parts will be recorded throughout the year. In this way, accurate data as to moisture changes in buildings will be obtained.

The foundation stumps consist of numerous types of timber, all being reject pieces from various laboratory tests. Similarly, the sole plates consist of pieces of pine or hardwood from the scrap heap, treated with creosote in the laboratory pressure cylinder. The ground around each stump was puddled with creosote.

One portion of the floor is being used to test, in a practical way, some results of laboratory tests on the various methods of milling flooring boards. Practice differs in different States. In some, the tongued and grooved edges are brought together on a face. In others, it is usual to undercut the boards so that the under-surface is narrower than the face. This results in an inverted V space being left between boards which only touch at the top. The object of this is said to be to take up any expansion with absorption of moisture and prevent buckling. Again, in some States, it is usual to cut grooves on the under face of flooring boards for the same reason.

In the experimental floor, these various ideas are being tested. Arrangements are made to determine the equilibrium moisture content below the flooring at intervals, and the behaviour of the surface is watched. It is hoped in this way to obtain definite practical evidence to replace the widely differing, but very positively held, ideas on these questions of flooring profiles.

Advantage has been taken of the purchase of fair quantities of the lower grades of timber, especially the reject grade, to carry out grading studies on the actual deliveries. These are yielding information of definite value.

By adopting smaller sizes, suitable grades of timber, special methods of construction, and proper planning of the work to avoid waste of time, it has been possible to erect these buildings at a very low cost. In many cases, building regulations prevent the adoption of perfectly sound economies in construction. In others, long standing prejudices have to be overcome. Neither of these factors should be allowed to operate in increasing the cost of building, and it is hoped to use these new structures as an illustration of how very satisfactory buildings can be erected of hardwood at a cost considerably lower than is usual.

Export Apple Cases.

During the years 1932 and 1933, investigations were conducted by the Council's Division of Forest Products and its Division of Plant Industry for the purpose of determining the relative merits of the two principal types of apple cases used for the export of Australian apples, particularly as regards the protective value of such cases against bruising. The investigations showed that the Australian dump case gives better protection to its contents than the Canadian standard case, and clearly indicated the desirability of carrying out experimental shipments. A full report of the investigations was published in the Council's Pamphlet No. 45.

The Committee of the Standards Association of Australia dealing with case standardization approved of the general lines of a large-scale experimental shipment in which it was proposed to ship a complete 'tween deck hold of about 7,000 or 8,000 cases. Unfortunately, it was found impracticable to carry out a full large-scale experiment, and

accordingly a small-scale test was arranged for the purpose of comparing the relative commercial values of the two cases. The main points on which it is desired to obtain further information are in regard to—

(*a*) The protection of the fruit against bruising.
(*b*) Other forms of wastage in the fruit.
(*c*) The appearance of the fruit in the cases.

A test consignment, consisting of 540 cases of Jonathan apples, of which one-half was packed in the Canadian standard case and the other half in the Australian dump case, was shipped by the s.s. *Port Fairy,* which is due to arrive at London on the 24th May. Of the 540 cases, 500 will be marketed in England, and the remaining 40 (20 in each case) will be subjected to detailed examination by officers of the Low Temperature Research Station, Cambridge. Officers at Australia House will arrange for a special wharf examination of the test consignment, and steps have also been taken in order to ascertain the market reaction to the consignment.

Some Tests on the Bactericidal Properties of Sheep Saliva.

(Contributed by C. E. Eales, B.Sc., Division of Animal Health, who is located at the Veterinary Research Institute, Parkville.)

Infectious entero-toxaemia of sheep is due to a sudden proliferation of the causal organism, *B. ovitoxicus,* in the small bowel and a consequent formation of the powerful exo-toxin. As *B. ovitoxicus* is found in the intestine of the normal sheep, some reason is sought for its sudden growth and toxin formation. The fact that outbreaks of the disease follow the appearance of green feed after the first rains (Bennetts*), and do not occur when the sheep are on dry feed, suggested to us the possible influence of the varying quantities of saliva secreted and carried with the two types of food to the intestine. The larger amount of saliva required for the mastication of dry food might have an inhibiting or bactericidal action on the organism. With this idea in mind, the following experiments were carried out to test the action of sheep saliva on *B. ovitoxicus* and also on *B. welchii* and *B. oedematiens.*

Fresh sheep saliva was mixed with an equal volume of physiological saline and filtered, first through a K pad in a Seitz filter and then through an L2 candle.

Filtered saliva was then added to tubes of liver piece broth in sufficient quantities to make 5, 10, and 20 per cent. mixtures of saliva with the medium. Tubes of liver piece broth plus saliva, as well as control tubes of plain liver piece broth, were sown from 24-hour cultures of *B. ovitoxicus, B. welchii,* and *B. oedematiens.* A saliva control was prepared by adding 2 c.c. of saliva to 10 c.c. of liver piece broth.

After 24 hours' incubation, all tubes except the saliva control showed growth. Later, the experiment was repeated, using 50 per cent. of filtered saliva. Again, all tubes except the saliva control showed growth in 24 hours.

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* Coun. Sci. Ind. Res. (Aust.), Bull. 57, 1932.

Conclusion.—Fresh sheep saliva, in quantities as great as 50 per cent. of the volume of the medium, did not inhibit the growth of *B. ovitoxicus, B. welchii,* or *B. oedematiens* in liver piece broth.

The negative results obtained in these *in vitro* experiments do not altogether disprove the theory of the role played by sheep saliva in the prevention of the disease as *in vivo* conditions must necessarily be very different.

Standing Committee on Agriculture—Meeting in Tasmania.

A meeting of the Standing Committee on Agriculture, at which some results of value were obtained, was held in Hobart in February last, after the meetings of the Inter-State Conference of Ministers of Agriculture. It was attended by the permanent head of each of the State Departments of Agriculture, the representatives of the Council being the members of the Executive Committee, the Secretary, and the Chief of the Division of Plant Industry. Professor A. J. Perkins (S.A.) was in the chair.

Tobacco Investigations.—A scheme of investigation in regard to tobacco as between Commonwealth and State was drawn up. This is discussed elsewhere (see page 120).

Status of Committee.—Some consideration was given to the status of the Committee and means whereby it could be made to play a more important part in the general improvement of Australian agriculture.

Standardization of Common Names of Grasses and Clovers.—It was reported that satisfactory progress was being made with the preparation of a list of common and botanical names of grasses and clovers as a preliminary to having their common names standardized throughout Australia.

Watery White in Eggs.—Reference was made to a report by Dr. G. Scott Robertson of the Ministry of Agriculture in Northern Island, in which the writer had reached the conclusion that watery white is almost entirely due to jolting in transport of the eggs. Several members present mentioned that evidence had been obtained in their respective States that this was not the full explanation in all cases, and it was left for the C.S.I.R. to organize an investigation in co-operation with the States.

Standardization of Agricultural Produce and Machinery.—The Committee gave some consideration to a statement prepared by the Standards Association of Australia in regard to (*a*) the standardization of primary produce, and (*b*) the standardization of wearing parts of agricultural machinery. The Committee expressed itself as wholeheartedly in favour of the objects behind the Standard Association's suggestion, and made various suggestions as to the best way in which the necessary actions to give effect to them might be taken.

Weed Pests.—It was considered that it is desirable to arrange for the publication of a Weeds' Manual for the whole of Australia rather than that each State should deal with the matter separately, and it was agreed that C.S.I.R. should collate and publish information to be supplied by the States. The Committee has in mind a publication containing an opening statement furnishing information regarding

methods of combating various weed pests, and then furnishing particulars regarding botanical names, common names, general descriptions, localities where found, and whether the weed has poisonous, injurious, or other properties.

Virus Diseases in Potatoes.—It was arranged that Dr. B. T. Dickson and a representative of the New South Wales Department of Agriculture should undertake a survey of the Australian position *re* virus diseases in potatoes, and should prepare a plan for the co-ordination and development of research work into certain aspects of the problem.

Dairy Research.—Some discussion took place in regard to the initiation of dairy research. The general tenor of the discussions was, however, that the time was not appropriate for any action to be taken with a view to the establishment of a National Dairy Research Institute.

The Tobacco Industry—Research and Demonstrational Work.

Following on a conference held at Canberra in October, 1933, action has now been taken by the Commonwealth Government for the re-organization of the experimental, demonstrational, and instructional work previously carried out by the Australian Tobacco Investigation Committee. The proposals made by the conference were discussed with the permanent heads of the State Departments of Agriculture at a meeting of the Council's Standing Committee on Agriculture held at Hobart last February, and as a result a satisfactory scheme for the allocation of the work as between Commonwealth and States was evolved, and has now received the approval of the Commonwealth Government.

The Government has decided that Commonwealth responsibilities as regards tobacco work are to be taken over by C.S.I.R. The salient features of the approved scheme are as follow:—

1. A sum of £20,000 per annum is to be made available for tobacco work for a period of three years, subject to review at the end of the financial year 1935-36.

2. The annual grant is to be distributed as follows:—C.S.I.R. to receive £5,000 per annum, New South Wales, Queensland and Victoria £3,750 each, and South Australia, Western Australia, and Tasmania £1,250 each. It has, however, been arranged that part of the sums unexpended by any of the States shall be available for any specially important work in other States.

3. C.S.I.R. is to be responsible for conducting research on disease problems affecting tobacco, including work on disease resistant varieties, and also for carrying out tests on smoking quality.

4. The States are to be responsible for field investigations of disease resistance, selection, yield, and quality improvement, and for instructional, demonstrational, and field experimental work.

5. The States will co-operate with C.S.I.R. in making facilities available for any necessary field work connected with the latter's investigations, and will supply C.S.I.R. with samples for the purpose of tests on smoking quality.

Steps are being taken by C.S.I.R. to give effect to the above scheme which affords an excellent example of the practical value of the work of the Council's Standing Committee on Agriculture in attaining uniformity of action as to important schemes of work, in preventing duplication of effort, and in maintaining close co-operation between the several parties concerned. In the future, so far as C.S.I.R. is concerned, tobacco will be treated in just the same way as any other crop. The Council will carry out investigations on disease problems, &c., while the States will be responsible for field and demonstrational work, &c.

A Cattle Breeding Experiment in North Australia—The Zebu Cross.

Some two years or so ago, in the Council's Pamphlet 27, Mr. R. B. Kelley, of the Division of Animal Health, gave an account of Zebu (Brahman) cross cattle, and discussed their possibilities in north Australia. Like his chief (Dr. Gilruth) before him, he was impressed with the work on the Zebu cross which he had seen in Texas on country very similar to many tens of thousands of square miles of north Australia, in particular, the northern coastal belt of the continent. In these localities, European breeds of cattle do not thrive, and the size, stamina, &c., of such breeds cannot be maintained without the regular introduction of fresh blood from the south. Mr. Kelley found that in Texas the problem of deterioration of British breeds has been overcome by the careful use of the Zebu.

Accordingly he recommended in the above-mentioned Pamphlet that the necessary Zebu cattle be obtained and a programme of investigation be commenced with them, in order to ascertain the value of their crosses under the particular conditions that applied there. This suggestion appealed to four large firms engaged in the cattle industry of the north, and in due course they arranged, in co-operation with the Council, for Mr. Kelley to re-visit Texas and to purchase the necessary stock whereby to commence the experiments. While in the United States of America, he was given valuable assistance on all sides, but particularly by the American breeders concerned, and, as a result eighteen head of pure-bred Zebu cattle (nine males and nine females) and one cross-bred bull were landed in Sydney in August, 1933. They have now gone through their various periods of quarantine and preventive inoculations, and have been distributed amongst the properties of the four firms where active breeding with them has commenced. The actual stations on which they are located are "Millungera," in the Gulf country, north-east of Cloncurry, "Waverley," some 120 miles north of Rockhampton, "Glen Prairie," 70 miles south-east of "Waverley," and "Wealwandangie," in the Springsure district west of Rockhampton. The last three stations consist of country considerably better than the average on which beef cattle are depastured within the Australian tropics, but later it is hoped to transport hybrids carrying various percentages of Zebu blood from these relatively favoured areas to areas less fortunate.

The whole experiment will be carried out under an agreement between the five parties concerned, namely, Messrs. Winter-Irving and Alison, Queensland Stations Limited, Meredith, Menzies and Company Proprietary Limited, C. W. Wright, and the Council for Scientific

and Industrial Research. Under the agreement, the cattle are owned by the four pastoral firms who supplied the funds for their purchase and for the travelling expenses of Mr. Kelley, but who, however, have agreed to conduct all the breeding operations under the guidance of the Council, to cull and destroy or sterilize such of the progeny of the cattle as may be required by the Council, and not to sell or otherwise dispose of the cattle without first obtaining the approval of the Council. The latter body, for its part, has undertaken to organize and supervise the experiment in such a manner that as many relevant data as possible will be collected. This work it has put under the immediate supervision of Mr. Kelley.

Naturally the whole experiment is a long-distance one, the results of which will not be determinable for a number of years. Not only the definite effect of the introduction of Zebu blood must be determined, but also the minimum proportion which will convey the desirable characteristics, yet at the same time maintain those of British breeds which make these breeds pre-eminent in the beef markets of the world.

It will also be realized that an important aspect of the work is the arrangement whereby no animals carrying any blood of the imported beasts will be introduced into Australia's cattle population without the approval of the Council, and naturally that approval will not be forthcoming until the Council is fully satisfied that the introduction would be advantageous.

The Dipping and Processing of Dried Vine Fruits.

The Council has recently received an offer by four packing companies in Mildura to subscribe the sum of £1,000 per annum between them for three years, to make possible an investigation into the fundamental principles of dipping and processing dried vine fruits, particularly sultanas.

After inquiries had shown that the services of an investigator able to study the various biochemical, physiological, and other problems involved would probably be available, the offer was gratefully accepted.

Mr. E. C. Orton, B.Sc., a graduate of the University of Western Australia, was chosen for the post. He commenced his studies in the Mildura district early in March last.

Supplement to the Catalogue of Scientific and Technical Periodicals in the Libraries of the Commonwealth.

The Council has just published a Supplement to the Catalogue of Scientific and Technical Periodicals in the Libraries of the Commonwealth. The original catalogue was issued in 1930, and was designed to assist workers in all branches of science and technology in ascertaining where the numerous references met with in the course of their studies might be consulted. It is particularly useful in a country of such large distances as Australia for research workers and others to be able readily to ascertain which libraries contain the particular periodicals they desire to see, especially as such periodicals are often comparatively rare.

The Supplement has been prepared along the lines of the former publication, and has been edited by Mr. C. A. McCallum and Mr. D. W. I. Cannam, both of the staff of the Melbourne Public Library, under the supervision of Mr. E. R. Pitt, the editor of the original catalogue.

The closing year for entries in the original volume was 1928, and although as many as possible received afterwards were included, the bulk of the entries were accurate to that year only. The period covered by the Supplement is therefore 1928-33. Although every effort was made to make the original catalogue complete, it was impossible in a pioneer work to achieve that aim altogether. On its publication, it acted as a checking list of the holdings for those libraries which had omitted an undue proportion of their periodicals either through the lack of cataloguing facilities or through uncertainty as to the exact scope of the work. The publication of a Supplement has enabled these omissions to be rectified as well as bringing up to date the information in regard to new holdings. It is also, of course, very useful in that it gives up-to-date information in regard to changes in old titles and to titles of new periodicals.

Copies of the Supplement (470 pages octavo) are now being sold at a price of 5s. each, which incidentally is below the cost of publication; the original Catalogue (1,232 pages octavo), together with the Supplement, may be obtained for 12s. 6d.

Recent Publications of the Council.

Since the last issue of this *Journal*, the following publications of the Council have been issued:—

Bulletin No. 77.—"Studies on the Phosphorus Requirements of Sheep, I.—The Effect on Young Merino Sheep of a Diet Deficient in Phosphorus, but containing Digestible Proteins and Vitamins," by Sir Charles Martin, M.D., D.Sc., F.R.S., and A. W. Peirce, B.Sc.

The work discussed in this publication was carried out by the Division of Animal Nutrition, and was aimed at determining the normal features of a phosphorus deficiency in sheep receiving food supplies adequate in all other respects. The information the Bulletin contains will thus be of value in further work on phosphorus deficiencies as such occur in the field, for it will serve to acquaint investigators with the nature of the symptoms which supervene on a deficiency of phosphate uncomplicated by the accompanying deficiency of protein with which this condition is usually associated under natural grazing conditions in Australia.

The effect of a simple phosphate deficiency is discussed under the headings of the general well-being of the sheep, the consumption of food, the effect on weight, the amount of inorganic phosphate in the blood, the calcium in the serum, haemoglobin, and wool production. A fairly lengthy section dealing with the characteristics, from the pathological and chemical points of view, of the bones of animals which had been on a phosphorus deficient diet for upwards of a year is also included.

Bulletin No. 78.—"Methods for the Identification of the Light-Coloured Woods of the Genus *Eucalyptus*" (Division of Forest Products—Technical Paper No. 12), by H. E. Dadswell, M.Sc., Maisie Burnell, B.Sc., and Audrey M. Eckersley, M.Sc.

This Bulletin describes the continuation of work which aims at the establishment of a key to the species of the genus *Eucalyptus*, the first portion of which, covering 37 coloured species, was published in Bulletin 67. In the present publication, 41 species of the pale-coloured eucalypts are described, and various keys for their determination are developed.

The results of the examinations of at least ten authentic samples from different trees of each species have been summarized in a short description of the timber of that species, and a number of photo-micrographs showing the typical structures of the different species are included. As an aid to identification, two types of keys have been developed, one intended more for the use of the practical man who does not have facilities for examining microscopic sections, and the other for the use of wood anatomists, particularly those overseas to whom Australian timbers are not familiar.

Bulletin No. 79.—"The 'Lucerne Flea' *Smynthurus viridis* L. (Collembola) in Australia," by J. Davidson, D.Sc.

When some years ago the Waite Agricultural Research Institute of the University of Adelaide established an Entomological Department under the direction of the author of this Bulletin, it was arranged that the Council for Scientific and Industrial Research would leave to the Institute all work concerning certain aspects of the lucerne flea problem, viz., the life history of the insect, its reaction to different environments, &c. Considerable progress has now been made in the Institute's investigations, and the University Council has agreed to the publication of the results of this work as C.S.I.R. Bulletin No. 79.

The publication discusses at length the possible geographical distribution of the pest in Australia, the discussion being mainly based on mean monthly rainfall, saturation deficiency, and temperature. Maps are given for each of the southern States of Australia showing the areas in which *Smynthurus viridis* can occur and those in which it may increase to economic numbers. Recommendations for dealing with the problem are also discussed.

Forthcoming Publications of the Council.

At the present time the following future publications of the Council are in the press:—

Bulletin No. 80.—"The Establishment, Persistency, and Productivity of Selected Pasture Species on an Irrigated Reclaimed Swamp," by H. C. Trumble, M.Agr.Sc., Agronomist, Waite Agricultural Research Institute, and J. Griffiths Davies, B.Sc., Ph.D., Agrostologist, Waite Agricultural Research Institute.

Bulletin No. .—"Studies on Drought Resistance in Grasses," by T. B. Paltridge, B.Sc., and H. K. C. Mair, B.Sc.

Bulletin No. .—"A Comparative Study of *Lolium perenne* and *Phalaris tuberosa* at varying Stages of Growth," by A. B. Cashmore, B.Sc. (Agric.).

H. J. Green,
Govt. Printer, Melbourne.